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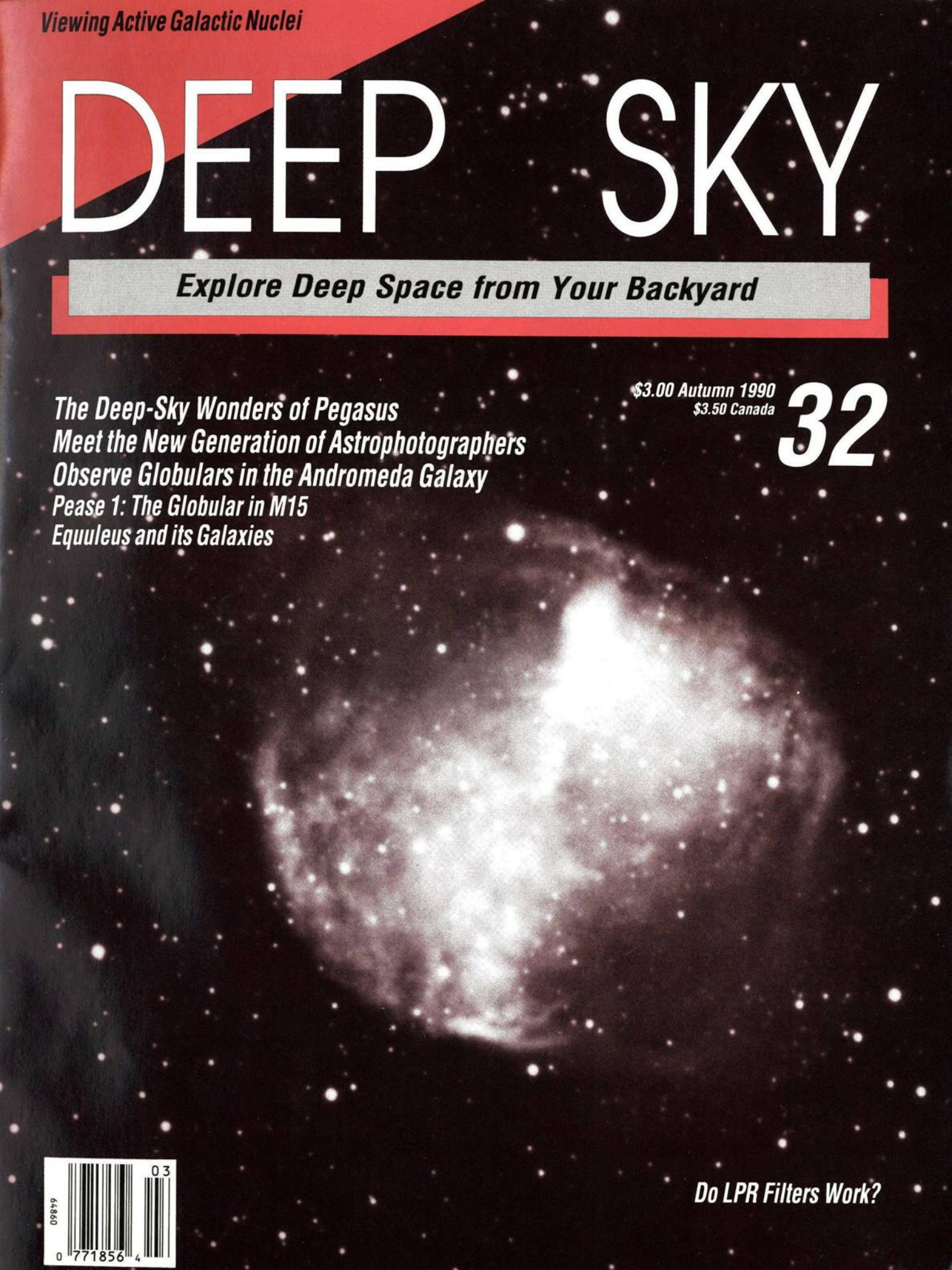

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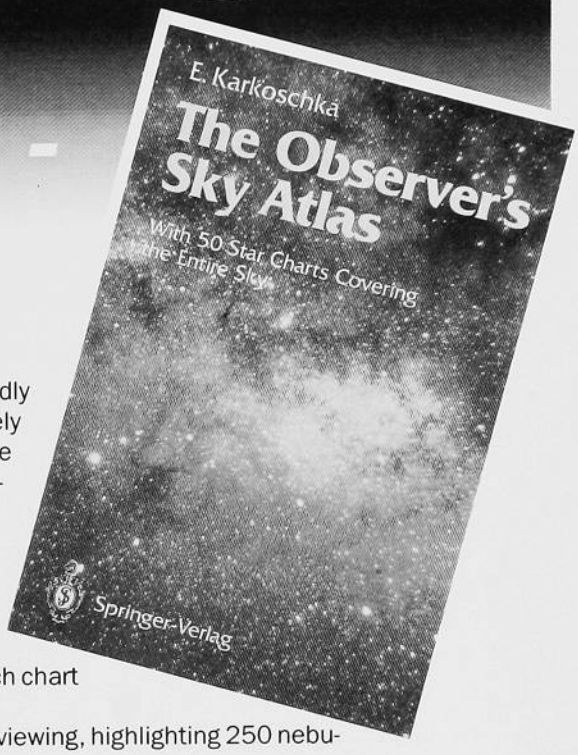

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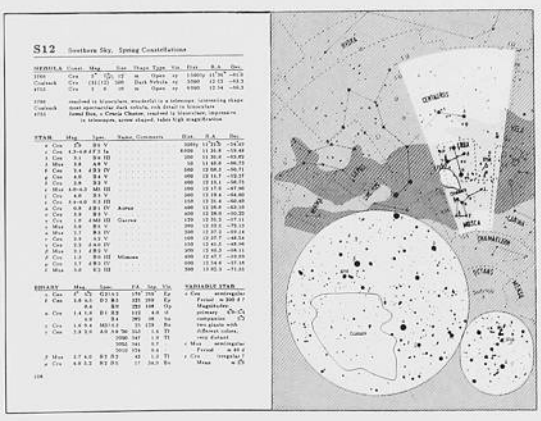

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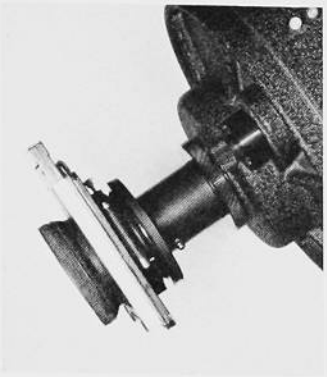

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MIRROR	COATING #1	COATING #2
10"	$ 475	$ 525
12.5"	625	700
16.0"	1800	2050
18.0"	2400	
20.0"	3500	

LIGHTWEIGHT 2.00" THICKNESS OPTICS

MIRROR	COATING #1	COATING #2
14.5"	$ 950	1150
16.0"	1200	1450
18.0"	1400	
20.0"	1750	
22.0"	3150	
25.0"	4950	

GALAXY'S ultra-lightweight mirrors (1.6") are made from fine annealed Pyrex mirror blanks and are manufactured to the same specifications as our 1:6 mirrors.

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16.0"	1050	1300
18.0"	1200	
20.0"	1500	
22.0"	2550	

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2.1"	$ 75	$100
2.6"	75	100
3.1"	95	120
3.5"	265	300
4.0"	285	325
5.0"	425	475

All mirrors are available in many popular focal ratios. Full thickness (1:6) and ultra-lightweight Zerodur® Optics available. Mirror refiguring services, write for quotation. For a complete product catalog mail $1.00 to:

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LUMICON Sky Vector™ (state scope) **$498**
Sky Vector™ Kit (you supply hardware) **$459**
Pair digital shaft encoders (for 2nd scope) **$149**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers perfer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F = 300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F = 500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle **$89.50**
1¼" straight-thru 80mm SUPER-FINDER **$169**
1¼" right-angle version, w/star diagonal **$195**
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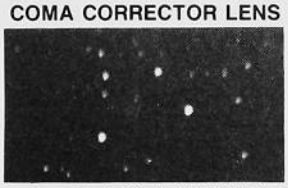
25mm Cross-hair 1¼" eyepiece (12X) **$29**
1¼" Star Diag. **$32**, 2" Star Diag., silver, **$159**
1¼" Amici Prism diag. for correct left-right views **$69.50**

COMA CORRECTOR LENS



Coma 1 inch off-axis (17½" f/4.5)

Same Field with LUMICON coma corrector lens; note smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener
2" lens **$285.00**
Extension tube for viewing **$26**
2" Easy-Guider™ (state camera) **$169.50**

NEW! ENCHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$29.95** 1.52" **$34.50** 1.83" **$39.50**
2.14" **$49.50** 2.60" **$65.00** 3.10" **$89.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.
1¼" (1.32" mirror) **$99.50**
2" (1.83" mirror)(see photo above) **$159.00**

OXYGEN-III FILTER

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both O-III lines at 496nm and 501nm.

Filter Type	1¼"	48mm
Lumicon Oxygen-III	$99.50	$199.50
Lumicon UHC	$99.50	$199.50
Lumicon Deep-Sky	$79.50	$119.50
Set UHC and Oxygen-III	$190.00	$380.00

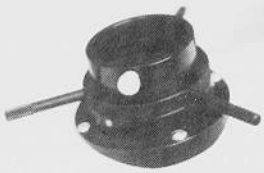
NOTE: The Oxygen-III Filter is not a substitute, but a compliment to the UHC Filter. **1 year guarantee:** You must see nebulae with the O-III filter that are **invisible** without a filter.

NEW ADJUSTABLE PIGGYBACK MOUNT

LUMICON has just designed a new adjustable piggyback mount ideal for all telescopes of 8-14" aperture. It has **both** vertical and sideways adjustment to allow optical alignment. It was designed to allow mounting of the LUMICON SUPER-FINDER on C-8, C-14, etc., but is ideal for any telephoto lenses or small telescopes.

Deluxe Piggyback Mount **$54.00**
(State Telescope Type)
LUMICON 12x80mm SUPER-FINDER $195.00

NEW! LOW PROFILE HELICAL FOCUSERS



LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.
LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.
Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD, SUPER-FINDER base plate.
LUMICON 1¼" Helical Focuser **$49.50**
LUMICON 2" Helical Focuser **$59.50**
LUMICON Non-rotating Helical Focuser **$89.50**
3 handles (see photo) for non-rotat. focuser **$12.95**
2" Rack & pinion low profile focuser **$129.00**
2"/1¼" adapter w/48mm filter threads **$20.00**
2" LUMICON EASY-GUIDER **$169.50**

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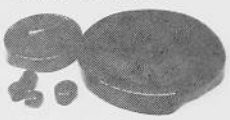

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12½", 12⅞"* **$15**
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†U.S. Patent 4,473,636

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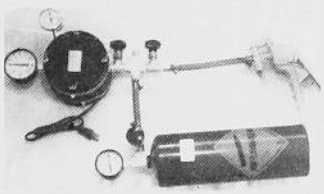

MODEL 600 HYPER-KIT (See Photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350.00**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller **$595.00**

Temperature controller for any HYPER-KIT **$65.00**

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All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms of bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent #4,448,500

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Full aperture. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$169.50**
3X Relay Diagonal (see photo) **$89.50**
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Guider for Hasselblad **$350**, Mamiya 645 **$199**

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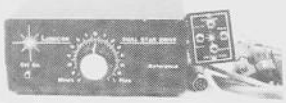

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3M 1000, fastest slide film	20	$12.95
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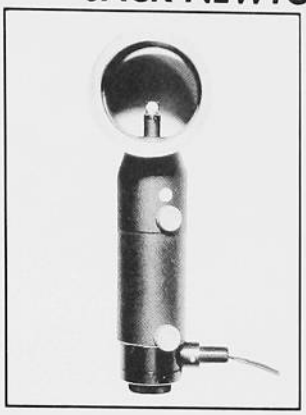

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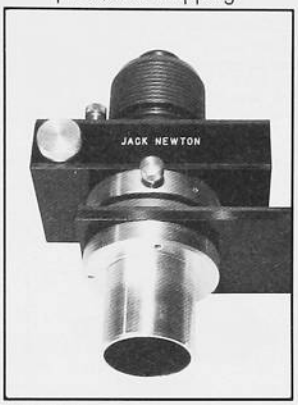

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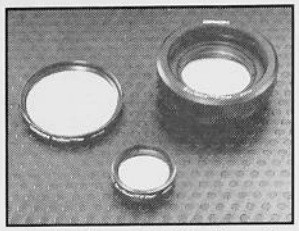

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Letters to *Deep Sky*

What's Happening in Deep Sky Observing?

by the readers of *Deep Sky*

AT THE EYEPIECE

Welcome to another issue of *Deep Sky*. As you can see, we've polished the layout and format of the magazine slightly to satisfy a number of reader comments — we hope you like what you see. It's very important for me to hear feedback from you, and I enjoyed meeting many readers this summer at events such as the Texas Star Party, Stellafane, and the Astronomical League convention in St. Louis.

This autumn offers an astounding array of objects for you are your telescope. For example, Brian Skiff and Paul Brown demonstrate in this issue's lead article that there are many little-known galaxies in Pegasus. Through Brian's unceasing efforts and the generosity of Harold Corwin the article contains data from the upcoming *Third Reference Catalog of Bright Galaxies*. After reading Brian and Paul's piece, head out under the stars, set up your scope, draw up a checklist, and see how many of these little buggers you can spot. We'd like to hear about your observations and will publish them in upcoming issues.

Another observational challenge is offered by none other than the Andromeda Galaxy itself. M31's exctensive network of globular clusters has lured large-scope users for many years, and David Higgins' article on page 24 provides observing notes and finder maps from Paul Hodge's excellent *Atlas of the Andromeda Galaxy*.

Last but not least, Dan Sheber and the Neville Public Museum Astronomical Society have produced a test report on currently offered nebular filters. This will be of great use to all deep-sky observers. Enjoy!

Dave Eicher, Editor-in-Chief

Taking the Bait

Dear Dave / I can't help biting when Gregg Thompson offers bait (Summer issue), consisting of his excellent photograph of one of my favorite objects in the LMC, comprising NGC 1761, NGC 1763, IC 2115, IC 2116, and NGC 1769, all enveloped in the emission nebulosity Henize 11. He's right: it's a glorious object in a small telescope. While it needs more publicity among amateurs, it is becoming a well-observed object by the rest of us, having recently been a prime object of study by radio, optical, and ultraviolet telescopes.

I also can't resist telling you how much I enjoy *Deep Sky*. Your standards, both editorial and scientific, remain at the highest level. — *Paul Hodge, Astronomy Dept., University of Washington FM-20, Seattle, Washington 98195*

Halo Observed around NGC 5128

Dave / Readers in both hemispheres might be interested in the observation of the bright Centaurus galaxy NGC 5128 I made at Las Campanas Observatory, Chile, during my three-week stay there in February-March 1990. This galaxy passes within 15° of the zenith from this extraordinary observing site.

When I swept to it using a 50x eyepiece on my 6-inch refractor (1.2° field) I was quite surprised to find that the large diffuse envelope surrounding the galaxy was plainly visible. The field was crowded with stars, so it was easy to find some to use as markers to define the size of this halo. The glow was elongated in position angle 35° by my estimate, and extended about two-thirds the distance to an 11th-magnitude star 17' southwest of the center of the galaxy, and west to a 10th-magnitude star 7' off the major axis. From these observations I infer an observed size of about 25' by 15'.

I confirmed these estimates using the "Whiteoak extension" of the *POSS* (only red-light exposures were taken in this zone) and the star magnitudes using the photoelectric sequences from the Space Telescope Guidestar Photometric Catalog, published in the *Astrophysical Journal Supplements*, **68:**1.

NGC 5128 and its incredible halo photographed by David Malin with the AAT. Courtesy Anglo-Australian Telescope Board.

The Surface Photometry Catalogue of the ESO/Uppsala Galaxies, by Lauberts and Valentijn, gives the position angle as 32°; since I did not know the orientation of the halo beforehand, evidently I saw the real thing.

Experience on galaxies with published surface photometry suggests my detection limit is near the visual magnitude 23 per square arcsecond isophote. According to Lauberts and Valentijn, the dimensions at the blue magnitude 25 (or V = approximately 24) per square arcsecond isophote are 31' by 24'; since I saw it somewhat smaller, this is consistent with a slightly brighter limiting surface brightness.

More importantly, my observation should not be considered extraordinary, but indeed should be expected in view of the published surface photometry. However, I do not know of any published visual observations of this halo, which I find surprising since it was so easy to pick up. As with so many objects formerly thought to be notoriously

difficult, the only requirements for seeing it are a fairly wide field and truly dark skies.

The main body of the galaxy had the appearance familiar from photographs, and indeed having seen so many photographs made it difficult for me to make an unbiased visual observation — the sort of thing where you see what you remember rather than what's perceptible in the eyepiece. The broad dark lane runs southeast-northwest through the galaxy (roughly perpendicular to the large halo), becoming filled-in toward the northwest end, where there is a hint of the bright streak superposed on the lane as seen in photos. The southwestern lobe is nearly a hemisphere and is brighter than the smaller northeastern lobe even though a 10th-magnitude star is superposed on the southwestern lobe. Other stars involved include an 11th-magnitude star in the dark lane near the galaxy's center; a 12th-magnitude star at the edge of the brighter part 4'.7 due north of center (the galaxy's center thus appeared about 9' across); and a 9th-magnitude star off the bright part south-southeast of center.

A nice, moderately-close pair lies about 10' east, known as h4587, and consists of two magnitude 9.5 stars separated by 5". About 1° southwest are the 12th-magnitude or 13th-magnitude galaxies NGC 5082 and NGC 5090/1, the latter appearing as a close pair in a common envelope of nebulosity in the 6-inch scope.

Although I viewed many southern showpieces in Chile — and NGC 5128 was one of the best — I'm keen on returning to complete a general survey of the southern sky. — *Brian Skiff, Lowell Observatory, 1400 Mars Hill Road West, Flagstaff, Arizona 86001*

The Hunt for Faint Planetaries

Dear Dave / Over the past few years Jack Marling and I have pursued a program of observing all of the planetaries listed in Perek and Kohoutek's 1967 work *Catalogue of Galactic Planetary Nebulae*. After eliminating scores of objects shown not to be planetaries and confining our search region to that north of -50° declination, we came up with 711 targets. When possible, Jack computed true visual magnitudes (accurate to within 0.2 magnitude) using the strength of various emission lines as published in the professional literature. If no data were available we estimated its visual magnitude and size at the eyepiece using our 17.5-inch scopes.

Because many of the faintest objects were not found on our first attempt, we'd like to encourage others to join in during our reobservation of these planetaries. If interested observers send $3 to cover copying costs, I will send them a catalog of the 711 planetaries in the *CGPN* including PK numbers, classification types, sizes, magnitudes, coordinates, constellations, and our observing results. If observations are then mailed to me, I'll include them in our project.

On another matter, I was pleased to find that in the Summer issue Phil Harrington highlighted several little-known planetaries. One of the objects discussed was NGC 6578, which Phil stated was located just north of the 5th-magnitude star 16 Sagittarii. Indeed, this is where it is plotted on Tirion's *Sky Atlas 2000.0*. A few summers ago I was quite frustrated with my inability to find this object. After determining that I could not have msised the field, I found that NGC 6578 is misplotted on the Tirion atlas. The planetary is actually located 7' northwest of *17 Sagittarii*. During the next star party I turned my scope to that area and immediately found the nebula. Apparently Tirion caught the error because the nebula is plotted correctly on his *Uranometria 2000.0*. My notes made with a 13.1-inch f/4.5 reflector reveal that the planetary was barely nonstellar at 144x, appearing like an out-of-focus 13th-magnitude star. Inserting a UHC filter created a noticeable gain in contrast, confirming the object's identity. NGC 6578 forms a "double" with a brighter field star approximately 20" to the west-southwest. Fortunately, 17 Sagittarii, in the field to the southeast, does not hinder observations. — *Steve Gottlieb, 1020 Ramona Avenue, Albany, California 94706*

Peculiar Planetaries

Dear Dave / In *Deep Sky* 28 Alister Ling reported on a sighting of the unusual nonstellar blobs in the planetary nebula NGC 6826 with his 8-inch Newtonian at 500x. This proves that you don't need a big telescope to "see" deeply into the universe. I liked his explanation of the visibility of the curious blobs very much.

Although I have never read a report on someone observing this phenomenon in NGC 3242, to me the Ghost of Jupiter exhibits this strange property. Starlike objects are visible as a faint brightening near the nebula's edge on each side across the long axis of the brighter nebula's body. Approximate position angles of this brightening are 125° for the southeastern blob and 315° for the northwestern blob. This isn't exactly opposite. At 280x with averted vision the curious objects blink on and off when compared to the central star. The southeastern blob seems a little brighter than the central star, while the northwestern blob is similar in brightness to the central star.

Keep forward *Deep Sky* crew. — *Miro Ilac, Iva Vojnovica 48, Dubrovnik 50000, Yugoslavia*

Three Cheers for Perseverance

Dear Dave / Having only subscribed to your magazine in the past year, I find it the best of the few publications available to the British amateur. I very much enjoyed the article by Alister Ling in *Deep Sky* #29 on Cassiopeia, which is one of my favorite constellations.

I live in a large town close to Gatwick Airport near London and do my observing with an 8.75-inch f/5.8 reflector. As you can imagine, the British weather can be frustrating to deep-sky observers, and it doesn't help that on the few clear evenings we often have low atmospheric haze that often persists for many hours after sunset. Nevertheless, on "good" nights I can locate 12th and 13th-magnitude objects.

Too many observers in Britain avoid any real attempt at deep-sky observing. It is not surprising when the average limiting magnitude is 3.8. But in many locations streetlights go off at about midnight, improving the local conditions. On nights that are poor to fair, I usually observe open clusters, but on good nights I go for galaxies and nebulae. I have managed to observe the reflection nebula around the Pleiades star cluster. I wish that more people would discover that they don't need perfect conditions — they can do a great deal of deep-sky observing from their own back yards. — *Colin Russell, 4 Glenview Close, Northgate, Crawley, Sussex, RH10 2AS United Kingdom*

Scoping Out Orion

Dear Dave / I have just received *Deep Sky* #29 and am very pleased with the magazine. Referring to Phil Harrington's article on deep-sky challenges, I think that saying the Horsehead Nebula is for 12-inch and 14-inch scopes is not right. I should think it is fairly easy to spot with a well-made 12-inch or 14-inch scope, as I have seen it with some difficulty with a 6-inch f/5 reflector at 60x. Here are my notes from that observation:

NGC 2024: Easily visible at 60x, with dark lane prominently visible.

IC 434: Very slight hint of its presence with averted vision. Extremely faint. A small break in IC 434, the Horsehead Nebula, flickers in and out of visibility. Very faint!

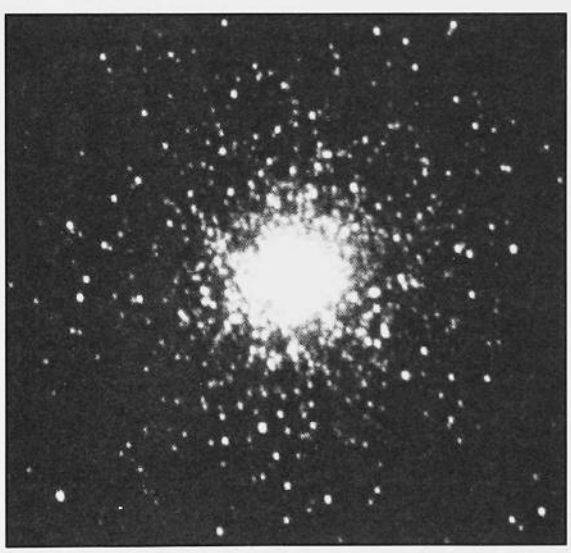
I also saw the reflection nebula NGC 2023. A friend of mine has seen the Horsehead Nebula in an 8-inch f/10 SCT well enough to sketch the object. — *Paul Brand, 36 Emerson Drive, Morayfield, Queensland, Australia 4506*

The Hidden Treasures of *Pegasus*

Explore the Square's Realm of the Unknown Galaxies

by Brian Skiff with Paul Brown

In the summer and fall of 1989 Paul Brown and I completed a survey of bright objects in Pegasus. The observing list included galaxies listed in the UGC with Zwicky magnitudes of 13.5 or brighter, as well as a number of fainter special cases already known to us, plus clusters, nebulae, and double stars. In comparison to our similar effort in Lyra (*Deep Sky*, Summer 1989), there was no problem scraping the bottom of the barrel brightness-wise to get enough to fill up an article. The problem this time was to cover all the reasonably bright objects, then select from them the most interesting ones attempting to highlight some not commonly viewed. Thus, for example, we omitted a discussion of Stephan's Quintet (all but one are below our magnitude cutoff anyway), and only briefly mention the Pegasus I galaxy cluster.



From a target list of over 70 objects, then, here is a selection of those we found more than ordinarily interesting. Just because an object is faint does not mean it is lacking in detail and large telescope owners will find many challenges here. But even the brightest examples reveal new detail upon careful, repeated observation.

As with the Lyra article, Harold Corwin provided basic data for the galaxies from the latest pre-publication version of the *Third Reference Catalogue of Bright Galaxies* (*RC3*). The data summarized in the table are substantially different in many cases from those published in the *RC2*, which served as a basis for the galaxy list in *Sky Catalogue 2000.0*, by Hirshfeld and Sinnott, and indeed in the *Observing Handbook and Catalogue of Deep-Sky Objects* by Luginbuhl and Skiff. We are grateful to have this up-to-the-minute information for the article.

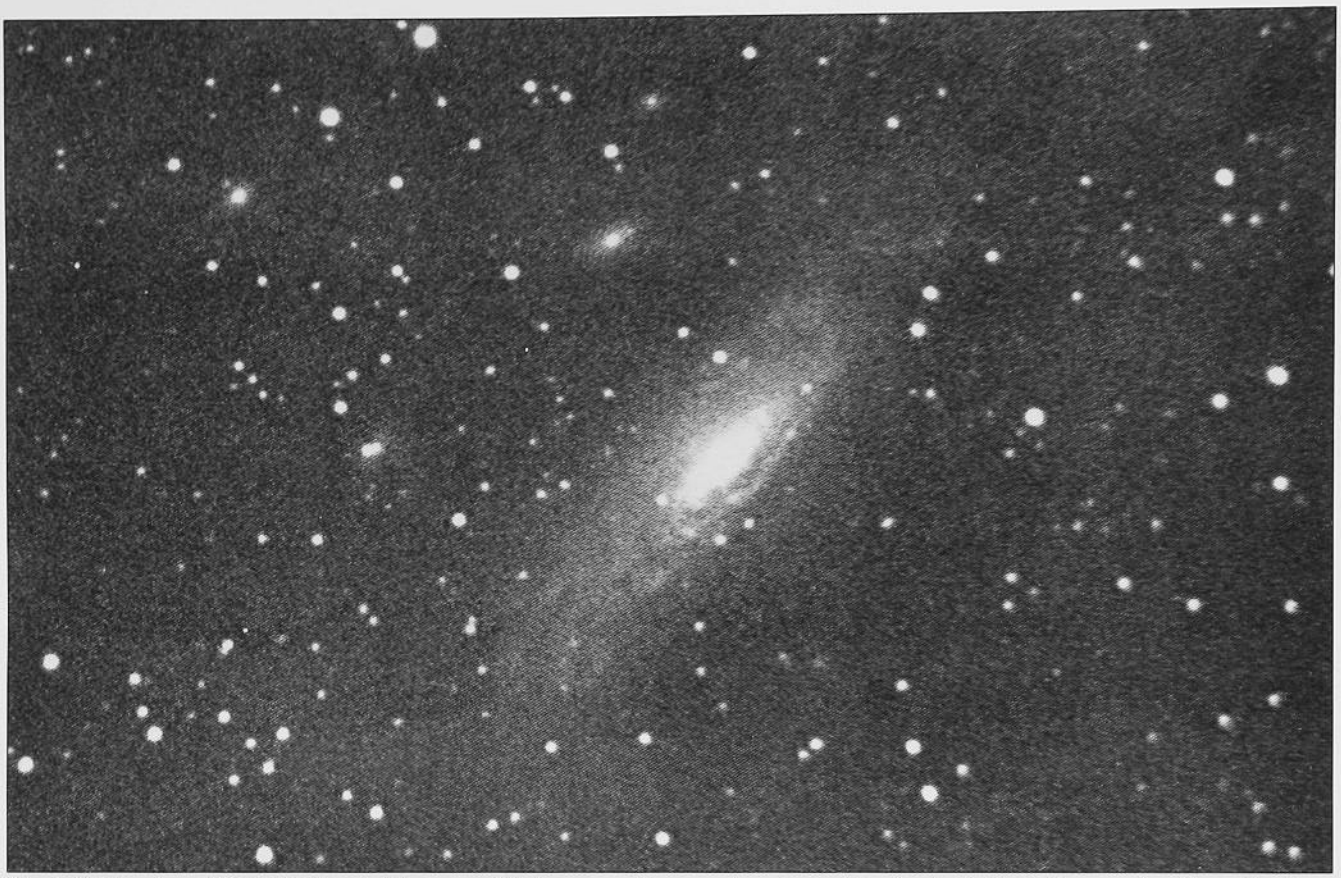
I should mention that none of the observations described below are contained in Luginbuhl and Skiff, but were made afresh without reference to earlier notes. Paul observed with a 16-inch Newtonian from his yard in rural Goderich, Ontario, and I from Lowell Observatory's Anderson Mesa dark site with a 6-inch triplet apochromatic refractor.

The only real showpiece object in Pegasus is **Messier 15** (NGC 7078), the large globular cluster not far from Epsilon (ε) Pegasi. It is a marginal naked-eye object, but I get only the merest glimpses of it from near-perfect skies. The cluster's brightest stars glow at V magnitude 12.6, meaning that it should be at least partially resolved in relatively small apertures from a true-dark site. One of the new high-performance refractors in the 3- to 4-inch range should do as long as high powers are used (try 150x to 200x).

On two occasions using my 6-inch refractor, the outermost stars in the cluster spread about as far as a V = 7.6 star located 6'.9 north-northeast of the cluster's center, from which an observed diameter of about 14' can be inferred. At just 30x, the brightness rises intensely toward a very bright star-like center. Although the cluster appeared quite grainy at this magnification, obvious resolution began at 50x, the stars appearing "very small," as the Herschels often described them. The concentration of stars in the outer parts is weak: the stars are uniformly distributed except for a relatively starless wedge in the inner halo, south-southwest diametrically opposite the bright star. Outside this wedge is an isolated V = 12.9 star (a non-member) 5'.0 from the center. The cluster's brightness and star density increase suddenly in the inner regions toward the nuclear pip, which at 150x was about 15" across and of very high surface brightness. At 300x this feature appeared broken down into bright clumps

A few hundred stars were resolved at optimum powers, including a little arc of four 13th magnitude stars in the inner halo on the northwest side, which were conspicuous at 150x. Owners of larger telescopes that can reach down to the horizontal branch of the cluster at V = 15.9 should see a dramatic increase in the number of stars, so the cluster's overall appearance will go from remarkable to astonishing.

Not far from M15 is **NGC 7094**, one of two low surface brightness planetary nebulae in the constellation. In tho 6-inch I found it without filters at 80x as an extremely faint haze around a magnitude 13.5 star. The nebula was confirmed using Lumicon UHC and O III filters, which I found



The bright galaxy NGC 7331 is visible in small telescopes; the complex cluster Stephen's Quintet lies nearby. Photo by Martin C. Germano (8-inch f/10 SCT, 103a-F film, 60-minute exposure). Opposite page: Globular M15 is the most-observed deep-sky object in the constellation. Photo by Martin C. Germano (8-inch f/10 SCT, 103a-F film, 25-minute exposure).

about equally effective in giving a weak-to-moderate contrast enhancement. I estimated the glow to be about 1'.5 in diameter, and with the UHC filter it appeared approximately uniform in brightness.

NGC 7177, one of the brighter galaxies in the constellation, is interesting because of several involved stars. The 6-inch showed a small but bright 1' by 0'.75 oval elongated roughly east-west with moderate, even concentratiobn. The 35"-diameter core was nearly circular. A magnitude 12.5 star lies 1'.3 south-southwest, and a magnitude 14.5 star to the southeast forms a triangle with the galaxy and the brighter star. In his 16-inch scope, Paul saw the core as oval at lower powers, but higher magnification revealed a 15th-magnitude star northeast of the suddenly much brighter center. Another 15th-magnitude star lies about 1' west of center within the halo, which appeared about 2'.5 by 1'.5 in extent overall.

Easily the brightest galaxy in Pegasus is **NGC 7331.** despite being visible in hand-held binoculars it still provides an observational challenge in tracing its outermost parts, which have a fairly low surface brightness. In the 6-inch, 50x and 80x showed this very faint outer fuzz as a fat oval with a 3-to-1 length-to-width ratio. The nebulosity extended out to the radius of a wide magnitude 13.5 pair 3'.1 north of the galaxy's center, implying an observed size of about 6'.5 by 2'.2. The position angle is 170°, or nearly north-south in orientation. At 150x the obvious part reached about two-thirds the distance of the closer of the two stars (or about 4' by 1'.75), and even this inner halo was very faint compared to the intensely bright core. Along the major axis the thin core reaches to a 14th-magnitude star off the minor axis northeast of center. The isophotes were distinctly flattened on the west-facing flank, reaching as far as a magnitude 15.5 star at the edge of the southwest flank near the core, for a size of 2'.2 by 0'.4. The nucleus was very small, perhaps 5" across. In his 16-inch scope, Paul saw the dark lane much better: the west edge of the core sits right on its edge, and there is a faint hazy streak west of the dark lane. His notes also indicate that the spiral arms were just discernable, particularly south of the center, where a weak, curled feature is apparent.

NGC 7332 and **NGC 7339** form a moderately bright pair of elongated objects in the same field, only 5' apart. Both were easy to pick up in the 6-inch, but NGC 7339 has a much lower surface brightness. At 150x, NGC 7732 appeared about 2'.25 by 0'.4 in position angle 155°, reaching halfway to an 11th-magnitude star 2'.25 south (the galaxy points nearly to it). The halo was broadly concentrated, but the 0'.3 by 0'.1 core showed moderately sharp concentration to a bright stellar nucleus. In his 16-inch scope, Paul saw the galaxy measuring 3' by 0'.7 overall with a much brighter, nearly circular core and stellar nucleus.

I saw NGC 7339 as somewhat larger than NGC 7332. NGC 7339 reached past a magnitude 14.5 or 15 star 1'.4 west and slightly south of the major axis and nearly as far as a magnitude 12 or 13 star well north of the east end, 1'.8 along the major axis. These data imply an overall size of around 3'.0 by 0'.4 in position angle 95°. The light had a weak, even concentration building to an oval core, but no sharp nucleus was evident: the core was almost uniformly bright. Paul noted that the halo has blunt ends instead of the pointed tips one usually sees.

Members in the galaxy group including **NGC 7463**, **NGC 7464**, and **NGC 7465** range from relatively easy to difficult. The group lies 25' or 30' due east of the brighter galaxy **NGC 7448.** Paul found NGC 7465 to be the brightest of the three, but I called it fainter than NGC 7463. Although it is much smaller and seemingly fainter than NGC 7463 on the *POSS*

Galaxy NGC 7479 is one pf the prettiest barred spirals in the sky. Spotting its arms requires patience, a moderate size telescope, and a very dark night. Photo by David Healy (14-inch SCT at f/6, hypered Tech Pan film, 45-minute exposure).

prints, the published photometry indicates I goofed. NGC 7465 forms a triangle with NGC 7463 and a 9th-magnitude star. Paul estimated the galaxy's size as 1'.2 by 0'.5, elongated south-southeast-north-northwest. The flattened oval had a much brighter core and substellar nucleus. NGC 7463 was very elongated east-west, and measured about 2' by 0'.5. Although generally diffuse, the galaxy's north-facing flank seemed sharply defined (there is no dark line here, however). The tiny, faint companion NGC 7464 almost touches it along the southeast flank 0'.7 from the center. It appeared as a compact circular object perhaps 30" in diameter.

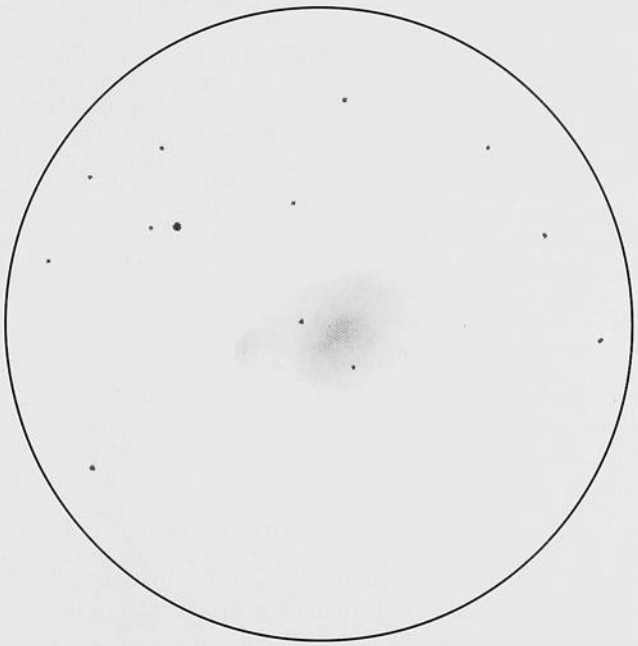
NGC 7479 is one of the most popular objects for viewing in the constellation, perhaps because of the distinctive nearly face-on barred spiral form in photographs. The picture is so commonly published that owners of larger telescopes have trouble not remembering it when making a visual observation. It is common to see drawings showing both arms curling off the bar in a symmetrical fashion, when they are not even close to being so, and are indeed rather difficult to view at all. After several attempts Paul succeeded in detecting the patch at the end of the arm curling west from the main body, but not without difficulty. He wrote, "how many would fill in the arc when sketching with small apertures?"

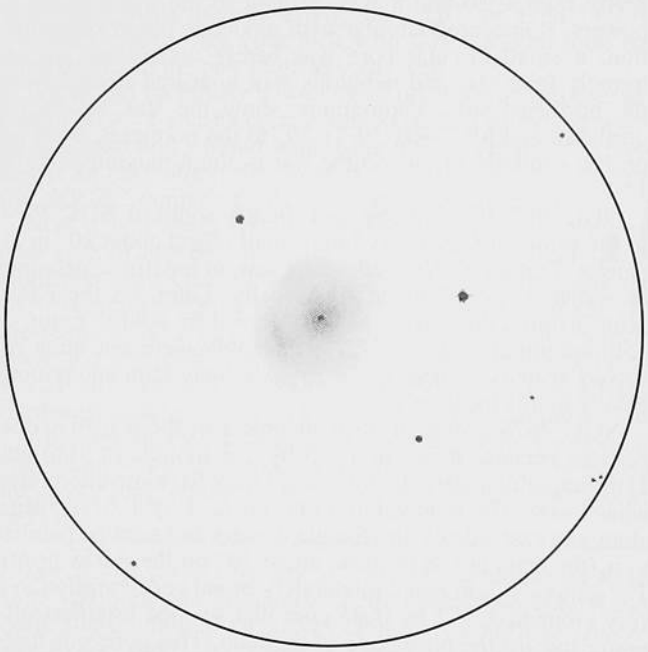
The galaxy lies at the north end of a string of bright field stars that are conspicuous when viewing the object with a very small telescope, such as a 2.4-inch or 3-inch refractor. But in larger apertures the field immediately around the galaxy is practically blank. In my 6-inch, I could see little more than the bar of the galaxy, which is elongated closely north-south. The narrow lenticular glow contained an approximately circular core and very faint substellar nucleus. At the north end of the bar is a V = 13.4 star; a V = 14.4 star lies just to the southwest. I found the arm curling around the magnitude 14.4 star westward from the south end of the bar only fleetingly visible at 150x; perhaps all that was certain was a patch in the arm lying approximately radially from the nucleus through the magnitude 14.4 star, and I connected it to the rest from memory of the photo.

Paul's drawing gives an excellent impression of some of the subtle features visible in larger telescopes. He estimated the overall size to be 4' by 2'.5; the bar alone was l'.5 wide. He noted a magnitude 15.5 or 16 star north of the center: large scale photos suggest this is possibly a star superposed on a bright knot in the galaxy. The same distance south of center is another fainter knot. The bar was generally patchy and soft nebulosity follows its full length.

It is beyond the scope of this article to give thorough descriptions of the entire Pegasus I galaxy cluster. The two brightest objects, **NGC 7619** and **NGC 7626**, are worth viewing even in small aperture, however. As the table shows, their types, size magnitudes, and average surface brightnesses are practically identical — but that makes them good target practice to help train yourself to spot subtle differences in objects. The galaxies lie just 6'.9 apart, and so can be viewed together at high power. I started by using 50x to reduce their apparent size in an attempt to detect a difference in brightness. The only real difference was that NGC 7619 had a conspicuous stellar nucleus whereas the nucleus in NGC 7626 was substellar. Going up to 150x, NGC 7619 appeared about l'.5 in diameter with strong sharp concentration to a nucleus lies a magntiude 13.5 star. NGC 7626 seemed slightly larger, reaching a magnitude 14.5 star 0'.9 west and slightly north of center, implying a diameter of about 1'.8. There was a strong even concentration across the center: no well-defined core or stellar nucleus, only the circular substellar spot at 150x.

About 2° east of the Pegasus cluster is an intriguing trio of





Top: NGC 7479; bottom left: NGC 7752-3; bottom right: NGC 7678. Sketches by Paul Brown using a 16-inch f/4.9 reflector at 250x.

Deep Sky Objects in Pegasus

Name	R.A.(2000)Dec.	Type	Size	p.a.	V	sfc	*U2000* Chart	Notes
NGC 1	0h 07.3m ,+27°43'	SA(s)b: II	1.6'x1.2'	120°	12.9	13.5	125	
NGC 2	0h07.3m , +27°41'	Sab	1.0'x0.6'	115°	14.2	13.6	125	
NGC 7078	21h30.0m , +12°10'	gc	12'	-	6.0	-	210	M15
NGC 7094	21h36.9m , +12°47'	pn	1.6'x1.5'	55°	13.4v	-	210	Pk 66-28°1
NGC 7177	22h00.7m , +17°44'	SAB(r)b I-II	3.1'x2.0'	90°	11.2	13.0	166	
NGC 7331	22h37.1m , +34°25'	SA(s)b I-II	10.5'x3.7'	171°	9.5	13.3	123	
NGC 7332	22h37.4m , +23°48'	S0 pec sp	4.1'x1.1'	155°	11.1	12.6	167	
NGC 7339	22h37.8m , +23°47'	SAB(s)bc:?	3.0'x0.7'	93°	12.2	13.0	167	
NGC 7463	23h01.9m , +15°59'	SABb pec	2.9'x0.7'	90°	13.2	13.8	213	
NGC 7464	23h01.9m , +15°58'	E1:pec	0.8'x0.8'	-	14.3_B	-	213	Arak 573
NGC 7465	23h02.0m , +15°58'	(R')SB(s)0°:	1.2'x0.8'	-	12.6	12.4	213	
NGC 7479	23h05.0m , +12°19'	SB(s)c I-II	4.1'x3.1'	25°	10.9	13.5	213	
NGC 7619	23h20.2m, +08°12'	E0	2.5'x2.3'	30°	11.1	13.0	214	Pegasus I
NGC 7626	23h20.7m , +08°13'	E: pec	2.6'x2.3'	-	11.1	13.1	214	Pegasus I
NGC 7674	23h27.9m , +08°47'	SA(r)bc pec	1.2'x1.1'	-	13.2	13.3	214	Arp 182
NGC 7674A	23h28.0m , +08°47'	S0 Pec	0.2'x0.2'?	-	14.9	11.1	214	Arp 182
NGC 7675	23h28.1m , +08°46'	SAB(s)0⁻:	0.7'x0.4'	-	13.9	12.5	214	Arp 182
NGC 7678	23h28.5m , +22°52'	SAB(rs)c I-II	2.3'x1.2'	5°	11.8	13.2	169	Arp 28
Jones 1	23h35.9m , +30°28'	pn	5.8'x5.2'	-	12.1v	-	124	
NGC 7742	23h44.3m, +10°46'	SA(r)b	1.7'x1.7'	-	11.6	12.7	214	
NGC 7743	23h44.4m, +09°56'	(R)SB(s)0⁺	3.0'x2.6'	80°	11.5	13.6	214	
NGC 7752	23h47.0m , +29°28'	IO:	0.8'x0.5'	113°	13.8	13.2	89	Arp 86
NGC 7753	23h47.1m , +29°29'	SAB(rs)bc I	3.3'x2.1'	50°	12.8B	-	89	Arp 86

Dimensions are for the B magnitude 25 per square arcsecond isophote. Position angles are mostly from the UGC. Total V magnitudes are listed, except those coded "B," which are total B magnitudes; V magnitudes for those objects will be 0.7 to 1.0 magnitudes brighter on average. Surface brightnesses are the mean values within the magnitude 25 isophote in units of magnitudes per square arcminute. The identities in the remarks column were taken from the *Principal Galaxy Catalogue* by Paturel et.al. True visual magnitudes for the planetaries are from Jack Marling.

objects best suited for large apertures. **NGC 7674** is the brightest object, and has the companions **MGC+01-59-81** and **NGC 7675**, all comprising **Arp 182.** My 6-inch observation made last autumn proved merely tantalizing — no matter how good the optics, sometimes you wish for a 24-incher. Although much the brightest of the three, NGC 7674 was pretty faint at so and it was difficult to see much at higher powers. It appeared circular with moderate broad concentration; a small circular core was barely noticeable. An extremely faint star and nebulous spot appeared fleetingly on the northeast side. Photographs show the star 16" to the northeast and MCG+01-59-81 30" to the northeast. Both appeared similarly bright, so the star is about magnitude 15 or 15.5.

NGC 7675 lies 2'.2 east and slightly south of NGC 7674. In the 6-inch it was a very faint, small object about 20" in diameter. Further to the southwest I saw an indefinite nebulous area that was hard to define visually. Later, on the *POSS* print, I found this region to be occupied by a large group of 15th-magnitude stars, which presumably were not quite resolved visually. (There is also an extremely faint anonymous galaxy in this location.)

NGC 7678 proved a difficult object in the 6-inch scope, perhaps because it lies in a 2'.5 by 1'.2 triangle of 10th and 11th-magnitude stars. In any case, I may have misinterpreted what I saw. The moderately faint, fat (2'.4 by 1'.6) oval lies along the east side of the triangle of stars and seemed parallel to it (the stars are in position angle 30° on the *POSS* print). The galaxy's light had a moderately broad concentration to a very elongated, 1'.2 by 0'.25 core that seemed brightest off-center toward the north side of the halo. This core was mottled with small spot. The halo reached slightly beyond the triangle star south and didn't quite reach the star to the north.

Paul's sketch, made prior to referring to a photograph, shows things more accurately. Southwest of the center of the galaxy is a bright and straight spiral arm, which he caught as an elongated patch in the halo. In my smaller telescope, I evidently discerned this and the bright core as a single feature. There is also a magnitude 14 or 15 star at the west end of this bright feature, 30" from the galaxy's center in position angle 250°.

The second large planetary nebula in Pegasus is PK 104-29°1, popularly known as **Jones 1.** It was discovered photographically about 1940 by Rebecca Jones at Harvard Observatory. Having successfully spotted NGC 7094, Paul challenged mo to try for this object in the 6-inch scope. I found a very slight brightening in the area at 50x without a nebular-filter. Both the UHC and O III filters were effective in enhancing the contrast (the O III was better), and even the broadband Deep Sky filter was useful. There was not much to enhance, though, and because it is about 5' in diameter, 50x was better at showing it. I convinced myself I could see a complete annulus with a thin rind and brighter knobs at position angle 170° and 350° bulging toward the inside of the rim. The southern of the two knobs was brightest, and it has some very faint (15th magnitude or so) stars south of it. The ring was very weak on the eastern periphery, and no central star was visible despite there being several faint stars in the field.

Checking a photo showed that the ring is all but invisible on the eastern side — a case of the eye completing a form despite the absence of stimuli — and that the knobs, while real and correctly placed, are merely bright parts of the ring, and do not bulge inward as I observed.

Galaxies **NGC 7742** and **NGC 7743** lie about 50' apart on a north- south line. Here is a case where the total magnitudes

If you squint and pretend hard enough, you can see the faint planetary Jones 1 in this photo. Jones 1 is the most chalenging nebula within the boundaries of Pegasus. Photo by Jack B. Marling (17.5-inch f/4.5 reflector, Konica SRV 1600 film, Deep-Sky filter and yellow filter, 50-minute exposure.

are very close, but the average surface brightnesses differ considerably. I found NGC 7742 distinctly brighter than its neighbor, consistent with its surface brightness being a magnitude brighter. The moderately-high surface brightness halo was about 1'.2 in diameter and showed moderate-to-strong even concentration; there was no distinct core or sharp nucleus. A magnitude 12.5 star was visible 1'.2 east-southeast of the center.

NGC 7743 lies in a field with several 10th, 11th, and 12th-magnitude stars and a single magnitude 13.5 star is visible at the southeast edge of the galaxy, 1'.0 from the center. I saw the halo as circular with moderate even concentration except for a moderately bright stellar nucleus that seemed about as bright as the star to the southeast.

Another interesting pair of galaxies is **NGC 7752** and **NGC 7753.** There are included in Arp's *Atlas of Peculiar Galaxies* as an interacting pair like M51, where the companion seems attached to the end of a spiral arm. They were fairly faint but separated in the 6-inch at 150x. NGC 7753 is the larger, brighter spiral galaxy, and it appeared about 1'.5 in diameter with weak broad concentration across a mottled halo, which was slightly elongated east-west. I saw a 15th-magnitude star at or near the galaxy's south-southwest edge. The companion was very small and much fainter, usually looking substellar, but with occasional glimpses of a circular glow approximately 15" in diameter.

Paul got a better view: NGC 7752 was about 2' by 1'.2, elongated east-west, with gradual brightening to a similarly extended bar-like core. He saw NGC 7753 as a faint glow elongated roughly southeast-northwest. Besides the 15th-magnitude star to the south-southwest, Paul also includes in his sketch a fainter star, about 16th-magnitude, on the north-northeast side of the larger galaxy. The brighter star is listed in the Longo and de Vaucouleurs catalogue of photoelectric observations of galaxies at V = 15.70 and B-V = 1.12. The B-V color is relatively red and its appearance on the red and blue prints of the *POSS* confirm that this is the star measured. However, since I saw it in the 6-inch, and Paul agrees it cannot be so faint as magnitude 15.7, we suggest it is closer to 15.0 (perhaps there is a typo for 15.07, or even 14.70). You may wish to try your luck with this star, and look for other details in the pair of galaxies as well.

We would be remiss if we closed off without an observation of **NGC 1** and its companion **NGC 2.** The two galaxies lie 1'.8 apart and I found both using the 6-inch at 150x. Neither is an easy object, but instead are very typical of the entire NGC/IC sample of galaxies: very small and faint.

NGC 1 was about 20" in diameter and seemed to have an oval core of approximately uniform brightness. Paul saw it elongated somewhat southeast-northwest, consistent with the *UGC* position angle of 120 °, and with a brighter middle. To the south, NGC 2 was very faint and substellar in the 6-inch, lying 1'.1 east and slightly north of a magnitude 13 or 14 star. Paul's 16-inch scope showed it elongated southeast-northwest again with only a bright central brightening.

Although this survey has not been exhaustive, we hope to encourage you to expand your repertoire of objects in the autumn sky and maybe even come home with a few special treasures.

Brian Skiff is an astronomer at Lowell Observatory in Flagstaff, Arizona, and co-author of the book Observing Handbook and Catalog of Deep-Sky Objects *(Cambridge University Press, 1990). Paul Brown is an enthusiastic Canadian amateur who lives in Goderich, Ontario, and enjoys observing double stars and sketching deep-sky objects.*

A Survey of Light Pollution Filters

Can LPR filters really enhance deep-sky observing?

by Dan Sheber

One of the biggest problems that amateur astronomers face today is light pollution. Many of us rely on portable telescopes to take us away from the ever-increasing glow of manmade illumination. Because of this, the hottest ticket on the astronomical accessory market is now some sort of light pollution reduction (LPR) filter. Screaming into existence several years ago, these filters promised to eliminate scattered artificial light while allowing the subtle light from distant deep-sky objects to pass unchanged. Because LPR filters captured so much interest after their arrival in the telescope cases of amateur astronomers, practically all of the big manufacturers got into the act, and now produce or market their "own brand" of LPR filters. How can observers choose from this bewildering array of products, all claiming to do the best job? Do LPR filters really help deep-sky observers anyway?

Recently I conducted a study of the LPR filters currently offered by manufacturers, ably assisted by many members of the Neville Public Museum Astronomical Society (NPMAS) in Green Bay, Wisconsin. We systematically tested each of the filters sent to us by the manufacturers both under the stars using multiple observer, double blind tests, and in the laboratory with the aid of a spectroscope. The resulting information is a long, detailed series of observational results for each filter under a variety of circumstances. We hope these results will provide you with the information you need to make a sensible choice if you purchase an LPR filter.

Compared with color filters, LPR filters are expensive. LPR filters cost more to manufacture because it contains as many as forty separate coatings in layers. These coatings are vacuum deposited one layer at a time with dielectric non-absorbing materials. Each layer is called a window. Each window acts like a mirror that reflects a specific wavelength of light and allows the remaining light to pass through. The wavelength bypass can be controlled by the thickness and composition of the coating for each window and by the amount of space between windows. The manufacturer must monitor the production of each window to assure the proper performance of the filter. If you own an LPR filter, try holding it to a light and tilt it. You'll see it changing colors. This is caused by the varying length of the light path through each window. Most manufacturers add an anti-glare coating to prevent ghost images and increase image sharpness.

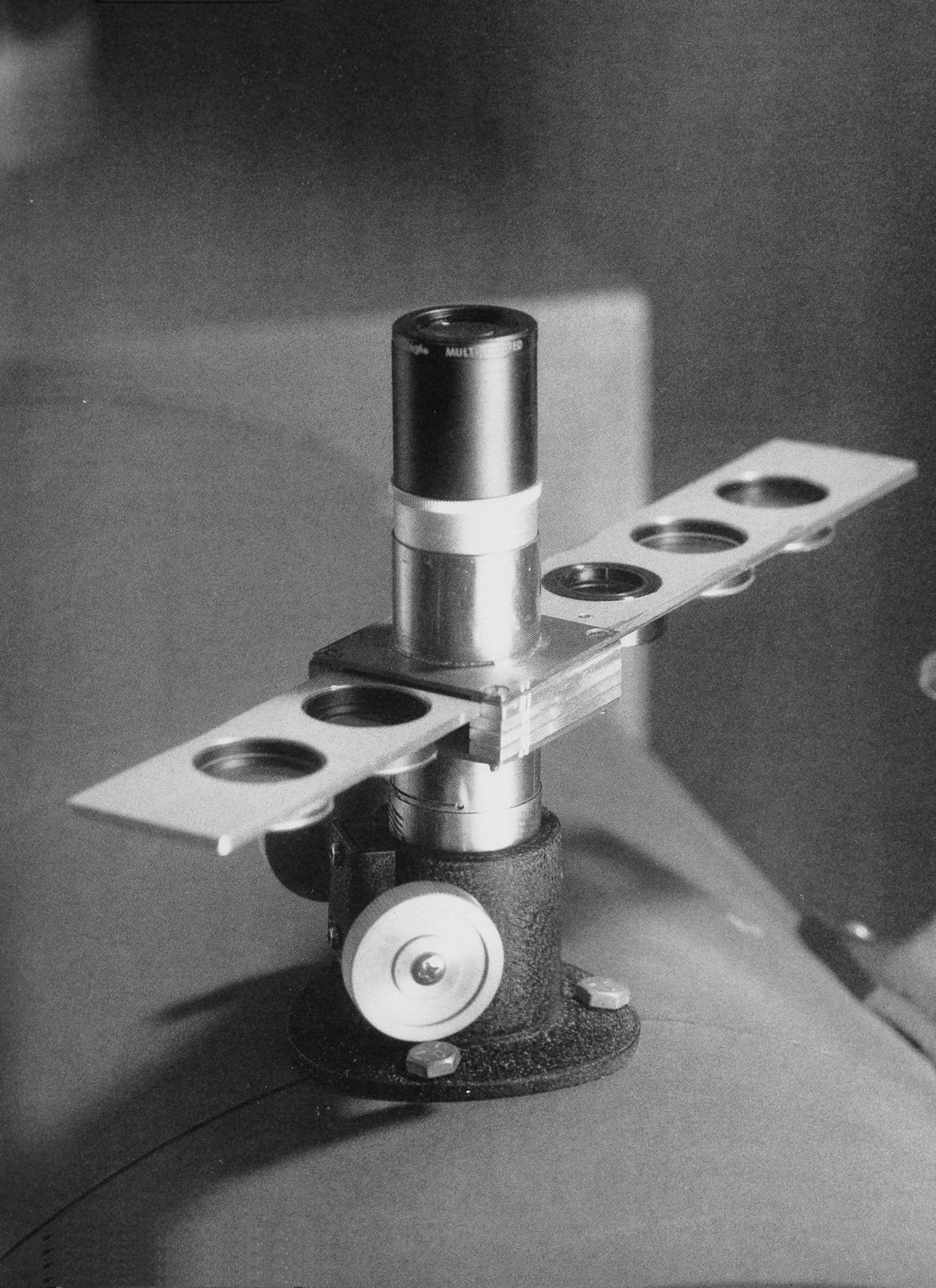
When using an LPR filter, it's critically important to keep it perpendicular to the optical axis of your telescope. If the same LPR filter is used on a 10-inch f/8 telescope and then on a 10-inch f/4 telescope, the two systems will perform differently due to the angle of light entering the filter. This difference is extremely slight, however, and probably not detectible to the human eye. If you look straight through an LPR filter, you will see violet, blue, green-blue, or blue-violet colors. These are the colors of light your filter transmits and those that deep-sky objects emit. Deep-sky objects also emit red light. The dark-adapted human eye cannot see this red light, but some LPR filters transmit red light for photography.

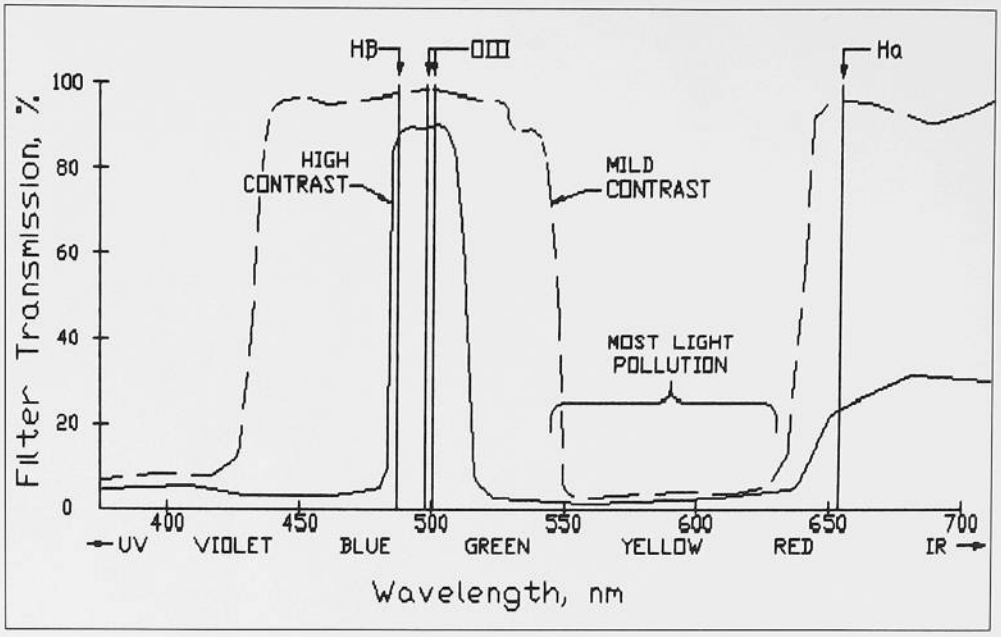
The unit of measurement for light wavelengths is a nanometer. The range of 400-700 nanometers is the area that concerns us, shown by the accompanying graph. The graph also shows how low and high contrast filters look to a spectrograph. The high contrast filter has a narrow band of transmission, while a low contrast filter has a broad band of transmission. In *Deep Sky* #15 (Summer 1986), Jack Marling provided a graph showing the range of light in nanometers detectable by the dark-adapted eye.

To begin our study, we obtained ten LPR filters and the accompanying literature from several manufacturers. NPMAS member Dan Klos coordinated this part of the project, and would like to thank the manufacturers for their assistance. Nine of the filters then went to the University of Wisconsin at Green Bay, where Professor Anjani Mehra ran spectrographs of the filters for us. The spectrographs indeed match the manufacturer's advertised spectrographs.

For our observations, Ted Kordes of the NPMAS manufactured a filter slide for us. The metal strip is exactly perpendicular to the eyepiece axis, allowing us to obtain unbiased results. The slide could hold up to six filters at a time. While observing, we used five filters and one empty slot so that we could see what the object looked like with no filter. The filters were labeled with letters A through J so that we would not identify them. A list of the filters, corresponding with their labels, was stashed away. We chose the blind test so that we could guarantee unbiased results.

We made visual observations at two sites, the first in the city of Green Bay, and from a mildly light polluted site 30 miles outside of Green Bay. We selected both of these sites so that we could determine if the intensity of light pollution would make a difference. As a result, the difference between the sites was slight for the high contrast (narrow band) filters. However, the low contrast





Graph showing the wavelength of light pollution and the wavelengths of key bands passed by nebular filters. All graphics in this article are by Dan Sheber and Steve Mofle.

(broad band) filters were affected. The mid-band filters were slightly affected.

We used several telescopes in order to see if size and focal length made a difference. We observed at a magnification that we felt was most suitable for each object. A 12.5-inch f/8 reflector was equipped with a 24mm eyepiece and a 12.5-inch f/4 reflector was fitted with a 12mm eyepiece. Focal length doesn't seem to make a noticeable difference in the performance of LPR filters. The longer focal length yields better sharpness, but that does not involve the filters.

We also observed some test objects with more than one telescope to see if the objective diameter made a difference. It didn't. The same filters performed best regardless of telescope size. Larger scopes did, of course, improve the brightness and resolution of the views.

Visual observations were made by Dan Sheber, Ron Parmentier, Don DeWitt, and George McCourt, all members of the NPMAS. An audio tape recorder was used at the observing sites to accurately record our observations. Over two and one half hours of recorded data was compiled for this report. The filters we tested were: The Parks LPB, the Daystar, Orion's Ultrablock, the Meade 908, Orion's Enhanced Skyglow, Lumicon's O III, Lumicon's UHC, Lumicon's Swan Band, Lumicon's H-Beta, and Lumicon's Deep Sky filter.

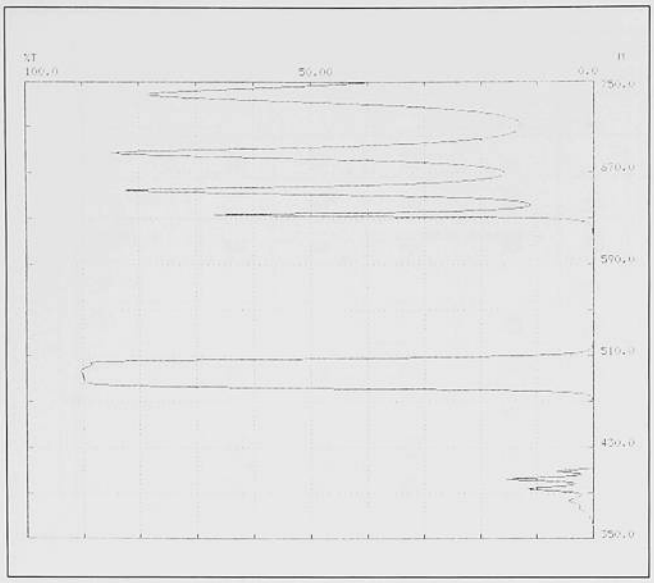
LPR Performance on Galaxies

A total of five galaxies (M104, M81, M82, M51, and M31) were observed with the filters. A 12.5-inch f/8 telescope was used for M81 and M82, a 30-inch f/13 telescope for M104, a 10-inch f/6 scope for M51, and an 8-inch f/5 scope for M31.

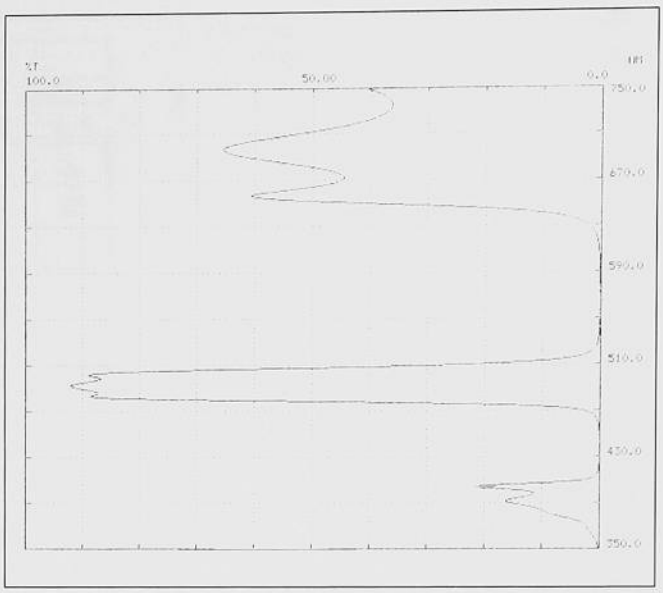
The O III seemed to diminish the galaxies' light intensely. The nucleus of each galaxy could be seen, but the outer regions were reduced in intensity to a point where averted vision was necessary. The Parks LPB filter performed well on galaxies due to its very low contrast. Surrounding stars showed well and the dark lane in M104 was clearly visible. Spiral structure could be seen in M51, M81, and M31. The detail in M82 was sufficient and the outer portions of M31 appeared nice. The Swan Band displayed more contrast than the Parks LPB. The galaxies were more difficult to see, but not as difficult as with the O III filter. The nucleus and brighter half of M104 was visible, but it was hard to see the dark lane and fainter half of the galaxy. The outer regions of M31, M81, and M51 faded out to nothingness. The Daystar filter dimmed M104 to a point where the nucleus and brighter half were visible, but the dark lane and fainter half were rather difficult to see. M51, M81, and M82 looked close to what they would look like with no filter, except with moderately high contrast added throughout the field. M31 looked good and the outer regions showed up well. The H-Beta filter blocked light throughout the whole field, was too contrasty, and caused difficulties in seeing even the brightest part of each galaxy. The galaxies looked at least two magnitudes fainter. The UHC darkened the field so that the nucleus was easily visible. Outer portions of each galaxy were elusive. We prefered not to use this filter for galaxies.

The Meade 908 added contrast throughout the field. M104 was seen in its entirety. The fainter half was slightly difficult to see but not uncomfortable to look at. M51, M81, M82, and M31 were all visible with this filter. The outer portions of these galaxies were seen at maximum contrast. The Meade 908 was a borderline acccessory for galaxy observing. The Ultrablock added tremendous contrast and light blockage (almost as much as the O III). All five galaxies were uncomfortable to view. We prefer not to use this filter for galaxies. The Enhanced Skyglow filter is a mild contrast filter and is favored on all galaxies. A little contrast is added throughout the entire field, and every star is seen with absolutely no problem. M104 can be viewed in its entirety (more features are seen with this filter than without). Spiral structure undoubtedly stands out while observing M51 and M81. Since this filter is mild, the observer can also increase magnification without adding too much contrast. Filaments are visible within the irregular galaxy M82. The spiral arms and dust clouds of M31 extend beyond a 1.5° field of view. M32 is a fairly bright fuzzball embedded at the outer edge of M31. The Deep-Sky filter is comparable to the Enhanced Skyglow and the Parks LPB filters. It displays a tad more contrast than the Enhanced Skyglow, but the faintest nebulosity at the outer edge of galaxies (M31 for example) is a little more difficult to see. The Deep-Sky filter works well on all galaxies.

We greatly favor the Enhanced Skyglow, Parks LPB, and Deep-Sky filters for galaxy observing. They all work very well. The Meade 908 and the Daystar filters work



Transmission curve for the Lumicon UHC filter.



Transmission curve for the Daystar nebular filter.

acceptably on galaxies but do not significantly enhance their appearance.

LPR Performance on Star Clusters

Two open clusters were observed, M11 and the Double Cluster. A 12.5-inch f/8 telescope was used for M11 and an 8-inch f/5 scope for both components of the Double Cluster.

The O III added extreme contrast throughout the entire field of view. The light emitted from faint stars was completely or almost completely blocked. The bright stars were dimmed with some color change (violet-red). Faint stars as well as bright stars were visible with the Parks LPB filter. This filter worked well on open clusters and added a little contrast throughout the field under moderate light pollution. The Swan Band added a little more contrast and light blockage than the Parks LPB. With the Swan Band some of the faintest stars became difficult to see. The brighter stars were very slightly dimmed and sharpened. The Daystar filter was similar to the Swan Band, although the stars looked a little sharper. An extremely faint patch of apparent nebulosity was noticed in M11. Since M11 doesn't have nebulosity, I probably just saw some glow from the stars (M11 is rich in bright stars). The H-Beta filter appears to block too heavily for star clusters. Both groups were dimmed and distorted to a point where they looked like a patch of nebulosity.

The bright stars were resolved with the UHC filter, but due to its very high contrast, the faint stars were either difficult to see or completely blocked. More stars in M11 were seen with the 12.5-inch telescope than with the 8-inch telescope. The Meade 908 filter was borderline for open clusters. It displayed pretty high contrast but didn't seem to block out any stars. Some of the faintest stars were difficult to see. Only the bright stars were visible with the Ultrablock filter. Like the O III and UHC, the Ultrablock dimmed stars considerably. The Enhanced Skyglow and the Deep-Sky filters both worked well for observing open clusters. All the stars within M11 and the Double Cluster were visible, although the field of view was darkened compared to a filterless view.

For open cluster observing, we tend to favor the Enhanced Skyglow filter, the Deep-Sky filter, and the Parks LPB filter. The Daystar filter, the Swan Band filter, and the Meade 908 filter are borderline performers. Other filters did not perform as well.

LPR Performance on Globular Star Clusters

Two test objects were selected for the category of globular clusters, M5 and M13. Both were observed with a 12.5-inch f/8 telescope at a resolving magnification.

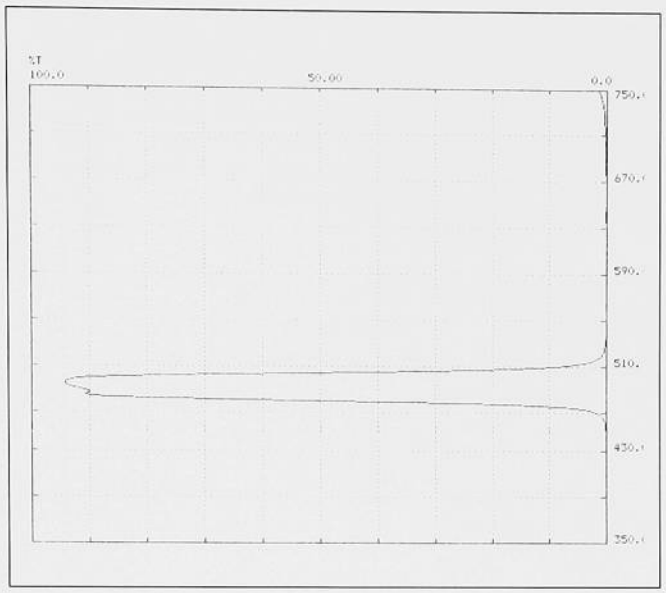
With the O III, M13 was hard to resolve. Its fainter stars were blocked while the bright stars were dimmed and slightly distorted. M5 looked like a fuzzball or a galaxy. The Parks LPB filter added contrast to the overall field without blocking out any stars. M5 and M13 were both fully resolved. More contrast was added by using the Swan Band filter. You needed to stare at M5 in order to see all the stars. When viewing M13, there was very slight blockage of stars. Any more contrast would probably have been too much for this type of object. The results of the Daystar filter were similar to that of the Swan Band filter, but the image seemed to look somewhat sharper. The H-Beta caused M13 to look like a faint galaxy (no resolution). M5 could be seen with averted vision, and looked like an elusive galaxy. The UHC was similar to the Daystar and Swan Band. The overall field was a little darker, and it was somewhat difficult to see several stars within both globulars.

The Meade 908 worked well with M13 and M5. It added contrast without blocking out any stars. The Ultrablock was identical to the UHC in performance for viewing M13 and M5. However, you'll get better results with no filter. The Enhanced Skyglow and Deep-Sky filters displayed a fine image of both globulars. The Enhanced Skyglow exhibited a slightly sharper image while the Deep-Sky filter delivered a bit more contrast.

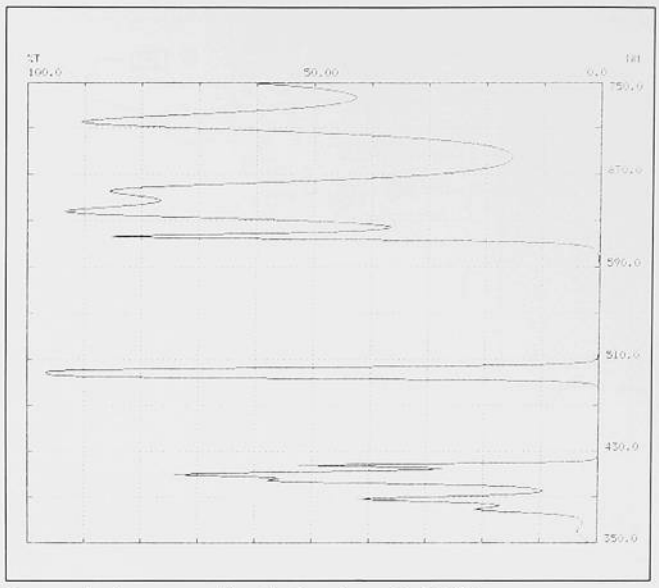
The Deep-Sky filter, the Parks LPB, and the Enhanced Skyglow filter are recommended for observations of globular clusters. The Meade 908 worked well also but should be limited to bright globulars. The Swan Band and Daystar can be used on the brightest globular clusters, but we do not strongly recommend it. Good resolution of globular clusters also depends on the diameter and focal length of the telescope.

LPR Performance on Planetary Nebulae

We observed M57 (the Ring Nebula), M27 (the Dumbbell Nebula), and NGC 7293 (the Helix Nebula) as test objects. A 12.5-inch f/8 scope and a 30-inch f/13 scope were used for M57 and M27, a 10-inch f/6 scope was used for M27, and an 8-inch f/5 scope was used for observing M57 and NGC 7293.



Transmission curve for the Orion Ultrablock filter.



Transmission curve for the Lumicon O-III filter.

The O III showed all three planetaries brightly with good contrast, although stars were difficult to see. It is favored for observing the Helical Nebula but seemed to add too much contrast and blockage of stars with M57 and M27. The Parks LPB filter was the opposite of this. On M57 and M27 the Parks LPB displayed a more natural view. It worked well at all magnifications and showed more contrast than with no filter. Surrounding stars were also visible. The Parks LPB filter did not work well on faint planetary nebulae such as the Helical Nebula. The Helix could barely be seen with this filter. Both M57 and M27 appeared nice with the Swan Band. This filter showed a good range of contrast. The Helical Nebula was more easily visible in the Swan Band than with the Parks LPB. The Daystar filter seemed to work well on planetary nebulae. Because it exhibited slightly more contrast than the Swan Band, faint planetaries appeared quite nice.

The H-Beta blocked out all three planetaries. This filter might work with some extremely faint planetaries. As far as we know, however, it does not work on this type of object. The UHC provided a little more contrast than the Daystar filter, but surprisingly did not work on the Helical Nebula.

The Meade 908 was similar to the UHC and the Daystar on the Helical Nebula. Its performance was similar to the Swan Band and Deep-Sky filters on M57 and M27. The Meade 908 can be used on all planetaries as well as the Daystar filter, but it is somewhat lower in contrast.

The Ultrablock performed best when viewing the Helical Nebula, followed by the O III. With the Ultrablock the entire Helix could be seen, including the dark center. M57 and M27 are bright with the Ultrablock. Good contrast was presented, with a slight blockage on surrounding stars. The Enhanced Skyglow works well only for bright and small planetary nebulae like M57 where magnification is needed. The Deep-Sky filter displayed a little more contrast than the Enhanced Skyglow and worked well with M57 and M27. It's a good filter for bright planetary nebulae.

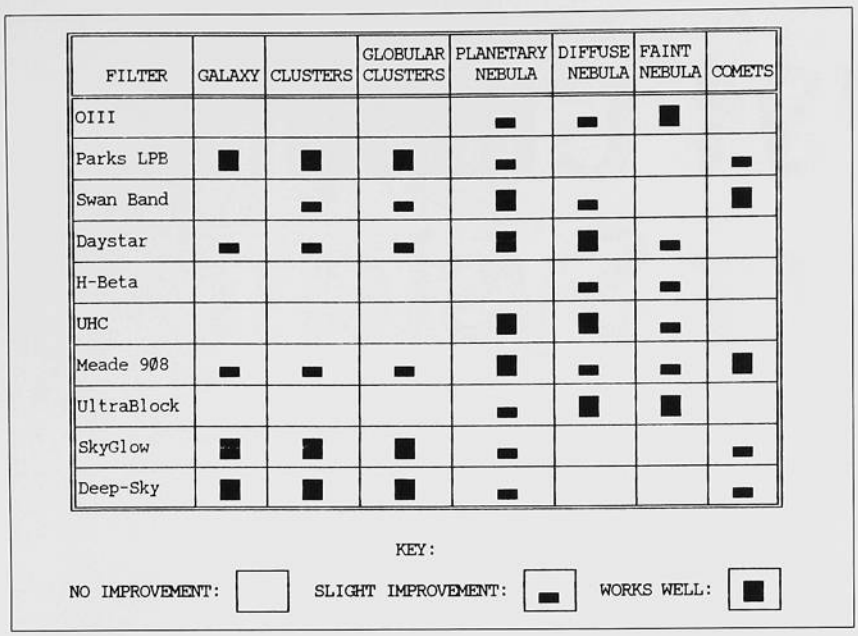
The Meade 908 and the Daystar filters are good mid-contrast filters for viewing all planetary nebulae. The UHC and the Swan Band work almost as well. If you only want to observe faint planetary nebulae, the Ultrablock and the OIII work well. If small and bright planetary nebulae are the targets, and when magnification is needed, the Parks LPB, Enhanced Skyglow, and the Deep-Sky filters would be good candidates.

LPR Performance on Bright Nebulae

We selected M8 (the Lagoon Nebula), M20 (the Trifid Nebula), and M17 (the Omega Nebula). A 30-inch f/13 scope was used to observe M17, a 12.5-inch f/8 scope was used for M21 and M17, and an 8-inch f/5 scope was used for M8.

The O III worked well on M8. This filter provided excellent contrast on bright nebulae, even showing outer regions of nebulosity. M17 looked rather good also, but the contrast was extremely high. Nebulous filaments in M17 appeared impressive at 200x through the 30-inch scope. M20 was visible with the O III but had almost too much contrast, leaving it not very sharp. The Parks LPB displayed a small improvement, if any, on all three nebulae. This filter is not recommended. The Swan Band offered a little more contrast and resulted in a brighter nebula. There was enough improvement on all three nebulae to warrant using this filter. The Daystar filter gave us more nebulosity and contrast than the Swan Band, and the stars were better visible. All three nebulae appeared rather nice; dark lanes were easily visible in M20, and filaments were obvious in M17 and M8. The H-Beta filter blocked out most of M17, but greatly helped the view of the Trifid Nebula (three dark lanes were clearly visible). M8 could be seen in its entirety by using the lowest magnification, but appeared a little too contrasty. All three nebulae appeared spectacular with the UHC filter. Good contrast, bright nebulosity, and many stars were visible in all three cases. The dark lanes within the Trifid were easily visible as well as the patch of reflection nebulosity located immediately north of the Trifid.

The Meade 908 filter worked rather well with M17 (good contrast and fairly bright nebulosity) and was similar to the Swan Band filter when observing M20 and M8. The Ultrablock filter delivered ideal contrast on M17. It was hard to take my eye away from the eyepiece. The entire Lagoon Nebula filled the field with beautiful nebulosity. The Trifid Nebula appeared very clearly including the dark lanes and the reflection nebulosity. The Enhanced Skyglow appears to be too mild for observing this type of object. The Deep-Sky filter offers a little more contrast than the Enhanced Skyglow, but still not enough to receive our recommendation.



This chart shows the overall effectiveness of ten types of nebular filters on various types of objects.

For bright nebulae we favor the UHC and the UltraBlock filter. The Daystar filter seemed to work quite well also. The O III, Swan Band, H-Beta, and the Meade 908 are borderline performers on this type of object.

LPR Performance on Low Surface Brightness Nebulae

Our test objects for this category were the North America Nebula (NGC 7000), the Veil Nebula (NGC 6960, 6979, and 6992-5), and the Cocoon Nebula (IC 5146). A 12.5-inch f/8 telescope was used for the Veil Nebula, an 8-inch f/5 scope was used for the Veil Nebula and the Cocoon Nebula, and a 2.5-inch f/5.6 homemade Zeiss scope was used to observe the North America Nebula.

The Cocoon Nebula could not be seen with the O III filter. This filter did perform well on the Veil Nebula, however. Magnificent rifts and filaments were easily visible. The entire North America Nebula was clearly visible and showed good contrast. The O III filter worked well on faint nebulae, but its capability was limited. The Parks LPB filter was too mild to work well on the Veil or North America nebulae, although a small amount of nebulosity was evident while observing the Cocoon Nebula. The Swan Band offered a little more contrast than the Parks LPB, but still not a very satisfying view. The Daystar filter worked well on all three nebulae but did not as well as some other filters. The shape of the North America Nebula was seen, but not as well as with the O III or Ultrablock. The Veil Nebula and the Cocoon Nebula appeared reasonably nice. The Cocoon Nebula appeared as a dim patch of nebulosity when using the H-Beta filter. This filter worked best at the lowest possible magnification. The Veil and the North America nebulae were faint due to high contrast and high blockage. I know that the Horsehead Nebula and the California Nebula are visible with the H-Beta filter from observations I made a few years ago. The UHC filter did not work well for observing the Cocoon Nebula (averted vision was needed). The entire shape of the North America Nebula was seen comfortably, with good contrast. The Veil Nebula looked moderately nice, but was not as detailed as with the O III filter.

The Meade 908 filter shows the stars and nebulosity rather well within the Cocoon Nebula, but the Veil and the North America nebulae were faint. The Ultrablock filter captured large amounts of nebulosity and good contrast from all three nebulae. Shape was distinctly visible while viewing the Cocoon Nebula and North America Nebula. Good detail is displayed while observing the Veil Nebula. The Enhanced Skyglow and the Deep-Sky filters were too weak for observing the Veil and the North America nebulae, although faint nebulosity was visible while observing the Cocoon Nebula.

We favor the O III and the Ultrablock for observing faint nebulae. The H-Beta was also made for this type of nebula but had limited capabilities. The Daystar, the UHC, and the Meade 908 are borderline performers for observing this type of object.

Final Words

The Dumbbell Nebula was observed to create an overall contrast scale. The results obtained through these observations reflect the taste of myself and other members of the test panel. Every object was at least 30° above the horizon during our observations. The Lagoon and Trifid nebulae were at the meridian during observations.

Regarding the construction of the filters, we like the method by which Parks and Orion include identification markings on the filters. It's too bad they don't offer a 2" filter. The Meade filter seems to scrape the inside of some focusers slightly , but we had no problems with it getting stuck. If a low-power, wide-angle eyepiece is used on a short focal length telescope, the Daystar filter seems to decrease the size of the apparent field, but not to a point where it bothered us (probably only 2° or 3°). The 2" Daystar filter doesn't have that problem.

When searching for the right filter to buy, ask yourself what kind of deep-sky observing you enjoy most. Does light pollution interfere with this type of object? How much contrast suits your taste? Hopefully this series of tests will provide enough knowledge to answer most of your questions and have an idea of what filter or filters will best suit your needs.

It is impossible for a filter to replace completely dark skies. Light pollution filters are a compromise between a completely dark sky, and your current light pollution situation. No filter will cause a 6-inch telescope to work like a 12-inch telescope, but the right filter will improve your views of most of the deep-sky objects that you observe.

Dan Sheber is an active deep-sky observer who enjoys the dark skies of northern Wisconsin. He works at the Neville Public Museum in Green Bay and is a member of the museum's astronomy club.

The M31 Globular Cluster System

Equipped with a large scope, you can spot twenty-one globular clusters suspended in the halo of the Andromeda Galaxy

by David Higgins

How often do you look at M31 during the course of an autumn observing season? Have you developed the attitude that once you've seen M31 there is just not much left to look at? Carefully observing and really *seeing* an object is different than merely looking at it. Soaking up all the information that an object, such as M31, has to offer requires patience, determination and practice. Of course knowing what you are looking at or searching for really helps. Having access to whatever material has been produced about a particular object and then observing when you get the chance goes a long way in providing you with the practice portion of observing deep-sky objects. Patience and determination you'll have to develop on your own.

M31 has intrigued and fascinated observers since the Persian astronomer Al-Sufi mentioned it in his *Book of the Fixed Stars*. Al-Sufi's A.D. 964 description of Andromeda's "Little Cloud," was the first recorded mention of the great nebula in Andromeda. Easily visible to the naked eye from a dark site, M31 was somehow overlooked by astronomers after Al-Sufi recorded it. Not until 1612 did the great nebula again gain the attention of an observer and find its way into a catalog describing nebulous objects. Using a small telescope, Simon Mayer, a German mathematician and astronomer, observed M31 and included it in his *Mundus Jovialis*, a pamphlet of descriptive observations.

Strangely, M31 again disappeared from the astronomical literature. Fifty years passed before it was included in a list of observations. In 1644 the French scientist Ishmael Boullian came upon M31 while looking for a comet. He included the great nebula in a publication that primarily discussed a long period variable star. Boullian was aware of the previous works of Al-Sufi and Mayer, and theorized that the nebula was variable due to its absence in the scientific publications.

Besides being one of the few real nebulous objects in the first deep-sky catalogs, M31 has the lone distinction of being the home of the first extragalactic supernova ever observed. One night in 1885 E. Hartwing used a 10-inch refractor at Dorpat observatory to look over M31 and observed a bright star only 16' from the core. Peaking at magnitude 5.4, nova S Andromedae was brighter than any normal nova that had been observed up to that time. At the time astronomers knew nothing of supernovae and to make matters worse, the nature and distance to "spiral nebulae" were unknown. Without this knowledge the distance and absolute magnitude of the nova could not be determined.

Although we take the spiral structure of M31 as an obvious fact, this was hardly the case in the 1880s. Spiral structure in nebulae had been observed and described by Lord Rosse as early as 1845. Using his 72-inch reflector Lord Rosse observed spiral structure in the face-on spiral M51. And even though M31 is much larger and closer it would take another forty years to detect spiral structure in Andromeda's great nebula. Because the galaxy is titled only 12.5° from edge-on, observing spiral structure in M31 would prove almost impossible if not for a budding new technology.

Photography was about to explode in the 1880s. Photographing through a 20-inch reflector, a Welsh amateur astronomer named Isaac Roberts shot several plates in 1887 that for the first time recorded the whole disk of M31. Prior to this time the sensitivity of photographic plates was so low that exposure times had to be extremely long and were sensitive enough to record only the galaxy's bright nucleus. Not only did Roberts find the nucleus recorded on the plates but also dark lanes surrounding the core. Roberts also recorded numerous star images embedded in the galaxy's soft glow. The belief that spiral nebulae were solar systems in the making was so entrenched in astronomical thought that any understanding of the significance of Roberts' M31 plates would have to wait until Edwin Hubble advanced the course of astrophysics in the 1920s.

The debate over the distance and nature of spiral nebulae was going strong when Vesto M. Slipher made a discovery that would put astronomers on the road to solving this mystery. In 1912 M31 played a pivotal role in the discovery that the vast majority of spiral nebulae were receding from us at enormous speeds. M31 is approaching us at 300 kilometers per second, a speed that at the time of its discovery was the largest velocity ever observed. The fact that most of the spirals are receding from us at such speeds led some astronomers to suggest that these velocities imply large distances. Even though an increasing number of astronomers believed that Slipher's work

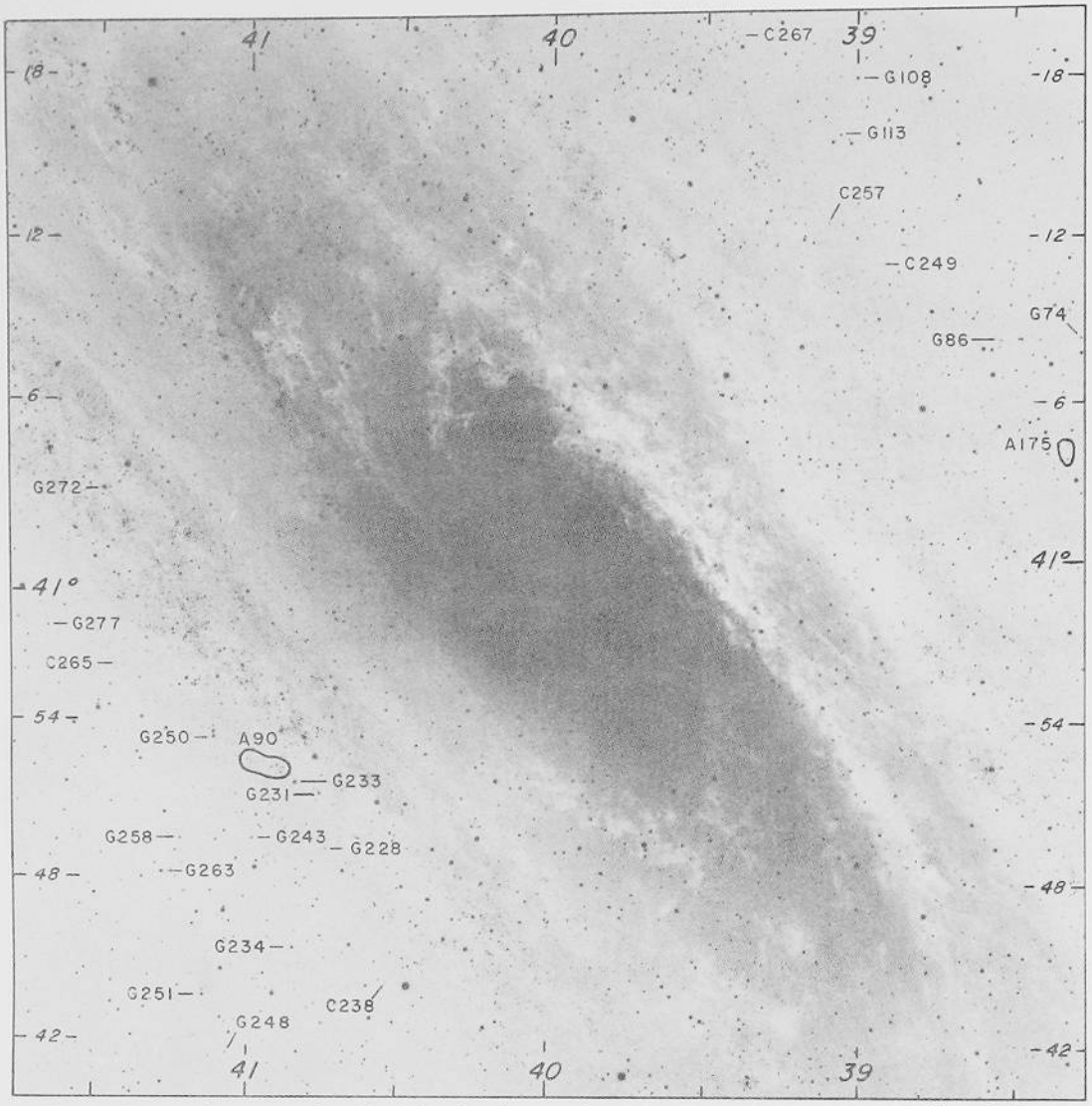


Chart 27 from Paul Hodge's Atlas of the Andromeda Galaxy shows a region around M31's core. Several clusters described in the article are visible here. Courtesy Paul Hodge.

went a long way in promoting the island universe theory, the distances to the spirals still were not known, and without this knowledge the relationship between the spirals and our own galaxy could not be determined.

Vesto M. Slipher also discovered that spirals are rotating. This was important evidence that would again lead astronomers to take seriously the island universe theory. But again the evidence was not conclusive enough to prove that the spirals were galaxies like our own Milky Way. The year 1912 was not only a year of discoveries that seemed to support the island universe hypothesis, it was also a year that saw the start of a study that became the dominating force behind proving that spiral nebulae were within and part of the Milky Way.

In 1912 Adrian van Maanan was appointed to the Mount Wilson staff were he undertook the project of measuring proper motions and parallaxes of stars. During his involvement in this project rotational and radial motions had been discovered in spiral nebulae. In 1915 van Maanan was asked to see if he could find any proper motions in the spiral M101. This project was along the same lines of his past studies so he undertook the project and proceeded to surprise himself and others in the process. Not only did van Maanen find proper motions in M101 but over the next ten years he found motions in a number of spirals. To detect these proper motions meant that spiral nebulae were close, so that many astronomers believed they were inside the Milky Way galaxy. Indeed many astronomers believed they were solar systems in the process of forming.

Although these data were accepted by most, studies conducted over the next ten years contradicted van Maanan's findings. But even with evidence mounting and questions that challenged the validity of van Maanan's data, several years passed before astronomers had hard evidence to support the island universe hypothesis. The final blow that indicated van Maanan's measurements were in error came when Edwin Hubble entered the scene. While photographing M31 and M33 in 1923, Hubble was able to resolve the outer spiral arms into individual stars. This was an exciting event to say the least but as a bonus he found a number of Cepheid variables, stars that had up to this time been found only in our galaxy and in the Magellanic Clouds. The light curves of Cepheids had been determined some years before and had been used by Harlow Shapley to determine the distances of the globular clusters which in turn gave us the outline of our own Milky Way galaxy.

By assuming that all Cepheids, regardless of where they are found, obey the same period-luminosity law, it was not difficult to determine the distance to M31. Although hesitant to publish his results at first Hubble knew that he had finally dealt a death blow to van Maanan's measurements of proper motions within the spirals. Published in 1924, Hubble's results caused quite an uproar. The majority of astronomers accepted and understood the

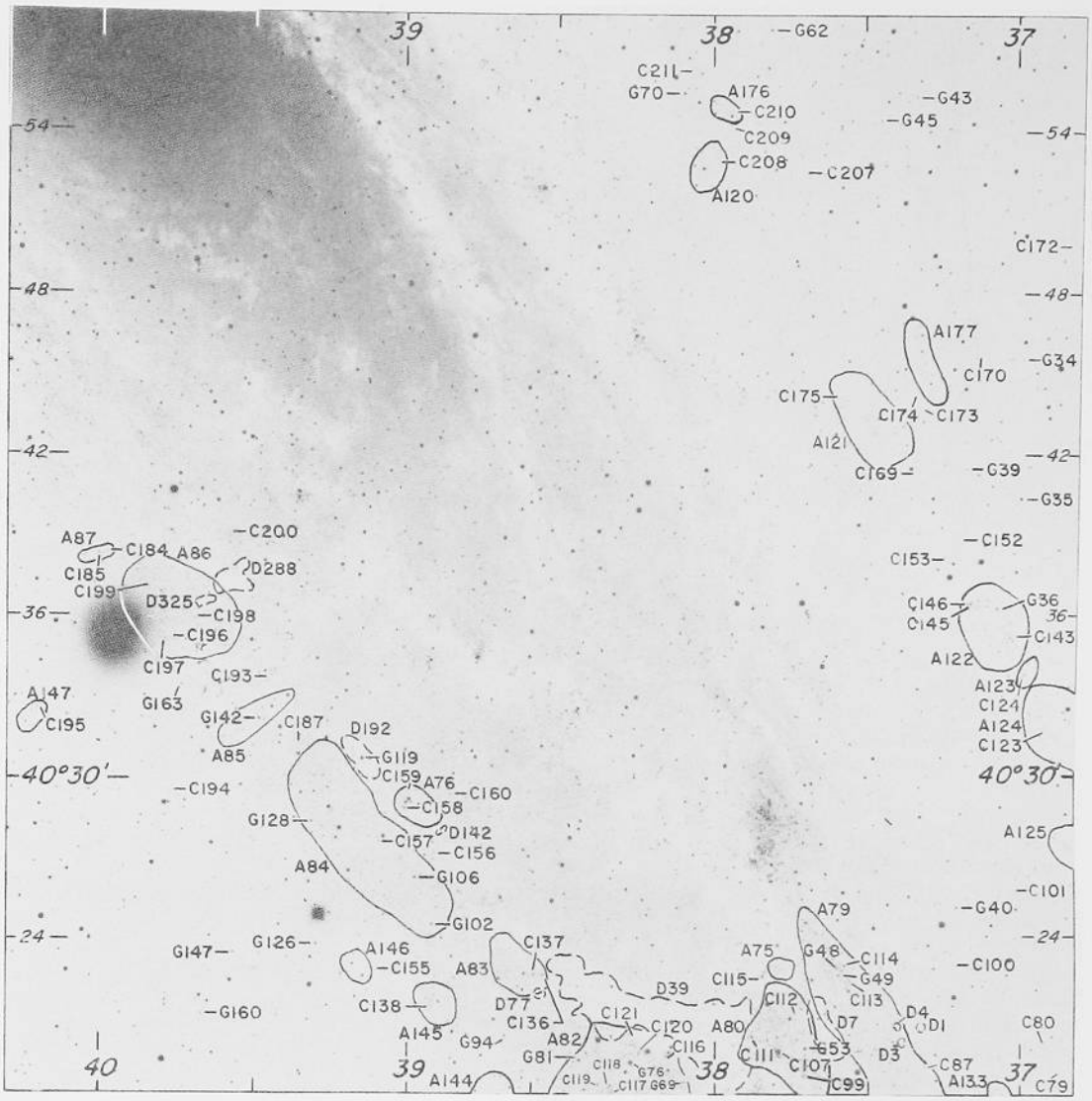


Chart 24 from the Hodge atlas shows the region of the M31 nucleus and satellite galaxy M32. Look for several of Higgins' clusters here.

significance of Hubble's findings but it took almost ten years for van Maanan's supporters to finally give way to the idea that the spiral nebulae were galaxies and the universe was home to countless numbers of Milky Ways.

Because M31 is so much like our own Milky Way it has its own compliment of deep-sky objects. Dating back to the time of Hubble, when it was determined that spiral nebulae were galaxies, studies have been made and continue to b e made, encompassing the many and varied objects that M31 contains. Of course these studies are published in the professional literature and difficult for most amateurs to find, and once found, hard to decipher. And even if you took a notion to try and find some of these objects finder charts for these faint objects are not always included so trying to figure out where and what to look for is also a problem. Astronomer Paul W. Hodge has alleviated this problem. His *Atlas of the Andromeda Galaxy* shows hundreds of objects of the same types in our own galaxy, much farther away and fainter of course.

The atlas consists of forty-one photographic charts that were taken at the prime focus of the 4-meter telescope of the National Observatory at Kitt Peak. The charts are divided into three sets that decrease in enlargement with two index charts that show the whole galaxy which in turn shows what area each one of main charts covers. The charts themselves are easy to use with a distinctive symbol that denotes each type of object plotted. A "g" is used to mark globular clusters, a "C" for open clusters, a solid outline for stellar associations, and a dashed outline for dust clouds. Plotted throughout the charts are 730 dust clouds, 188 stellar associations, 403 open clusters, and 355 globular clusters. Globular clusters have always fascinated me, so it didn't take long to put the atlas to good use. I spent the biggest part of the fall observing season searching for globulars with a 24-inch f/4 reflector and Hodge's atlas.

The dust clouds and stellar associations are very difficult if not impossible to observe. I think these objects are strictly in the realm of photography. The exception to that statement is the huge stellar association NGC 206. Easily visible in amateur scopes, NGC 206 lies at the southwestern tip of M31. The dust clouds are in the same category as the associations, very difficult if not impossible visually. There are open clusters visible in backyard scopes and I have found several but I have not devoted much time in tracking them down. That will be the subject for another project during next autumn's observing run. That leaves the brightest and easiest objects to observe in M31: the galaxy's extensive globular cluster system.

M31's globular cluster system is so much like our own that these extremely distant globulars give astronomers the opportunity to observe and test theories about the creation of the universe and the conditions that existed after the Big Bang. Globular clusters in M31 are metal poor, which means they contain a very low ratio of heavy

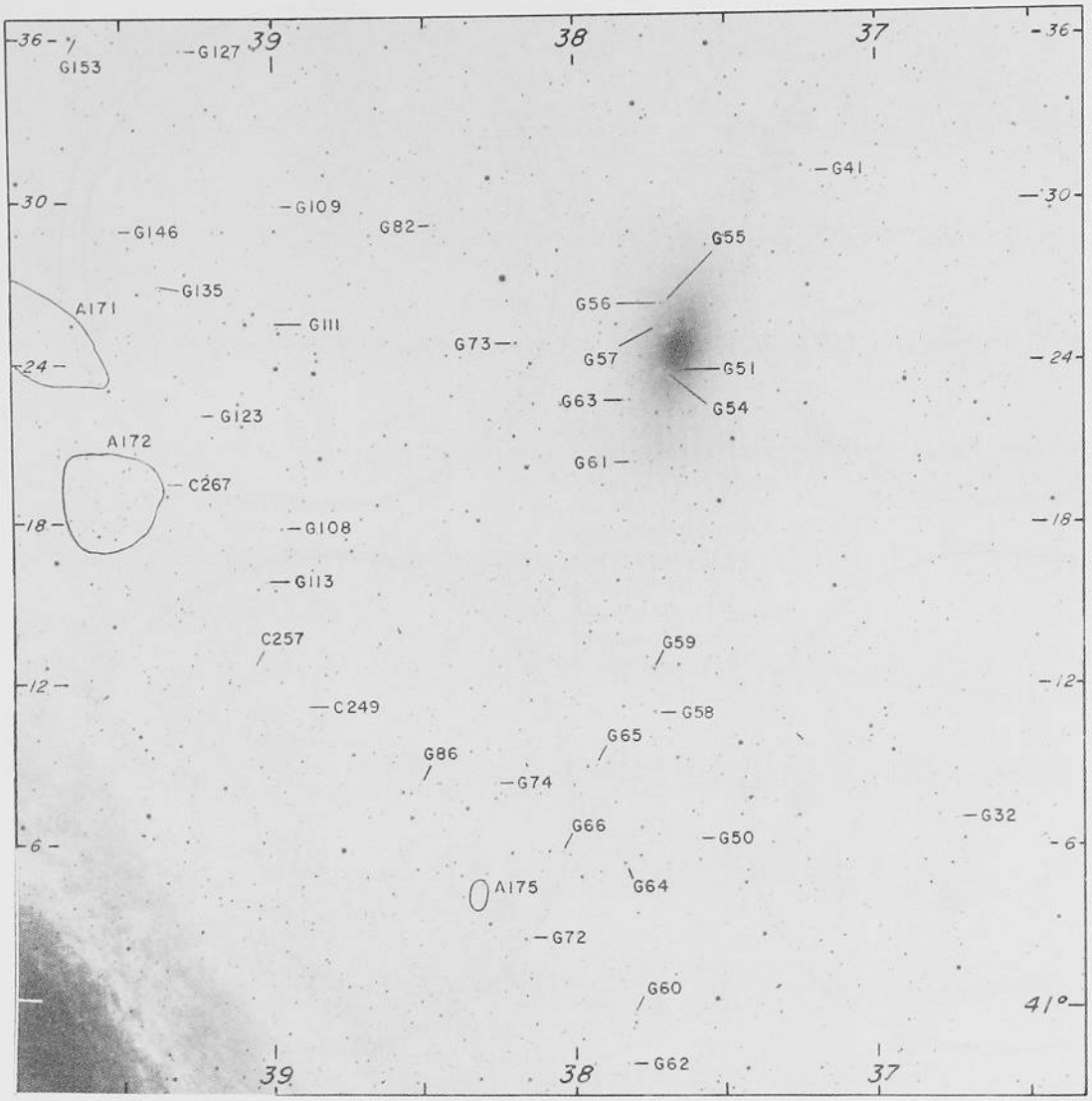


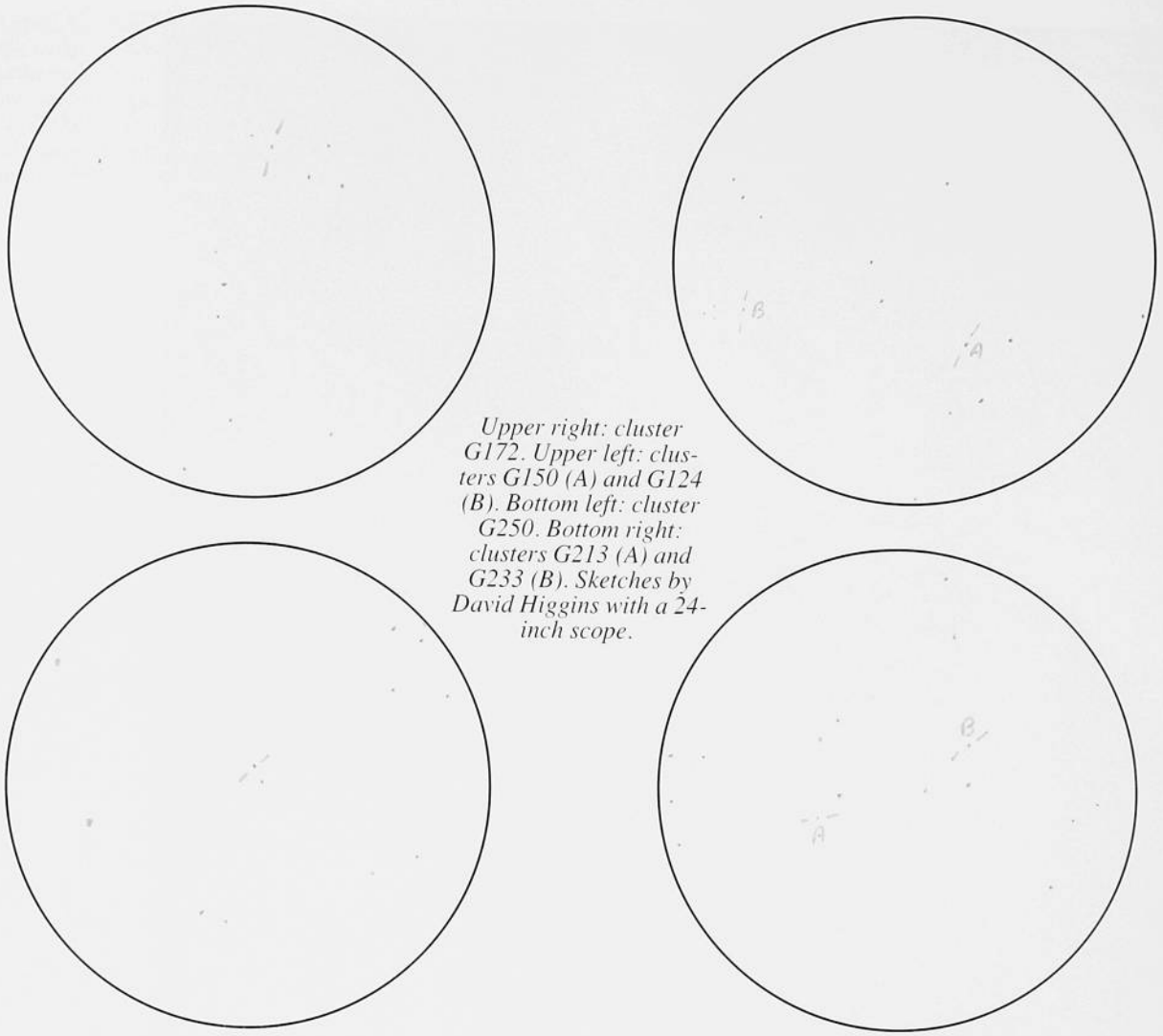
Chart 23 from the Hodge atlas shows the region surrounding satellite galaxy NGC 205. Several of the Higgins clusters are visible in this area.

elements to hydrogen in their stars. The stars in globulars are old Population II stars that have used up much of their hydrogen fuel. The globular clusters of M31, much like our own cluster system, orbit about the galactic center and occasionally each one plunges through the disk of M31. This sweeps out dust and gas, leaving it in the disk of M31 and stripping the globular clusters of heavy metals.

Visually the M31 globulars are no more that faint stars. Ranging from magnitude 13.7 to almost 19th magnitude, most of these globulars are not within the visual range of amateur scopes. But don't let the faint magnitudes dissuade you. Some of M31's globulars are visible in a 12.5-inch telescope and will provide you with a fascinating observing program. Whatever size telescope you are using, high magnification will be the key to spotting these clusters. You're not looking at a faint fuzzy, but rather a concentrated light source — what you're seeing is the central core of the globulars. Don't expect to see any of the surrounding stars around the periphery of the cluster. Remember that you will be looking through not only our galaxy's gas and dust but in some cases M31's.

These globulars are not plotted on any of the popular star charts and even if you had the coordinates most star charts have such small scales its impossible to plot them by hand. What you really need is Hodge's *Atlas of the Andromeda Galaxy*. This work will give you a good deal of the necessary information and large scale charts that are needed to track down some of these elusive clusters. Several other sources of information are available that will provide you with the rest of the information needed to round out the material required for successful observations. An article by Brian Skiff in the 1984 autumn issue of *Deep Sky* provides a great deal of information on this matter. Brian provides a number of objects in M31 and includes in his lists several globular clusters and their magnitudes. He also includes a photograph of M31 with different types of objects plotted on it. Although not as detailed as Hodge's plates, this photograph and the information included in the article form a good starting place until you can get your hands on the Hodge atlas.

An additional piece of material that contains a wealth of information is found in a paper published in the January 1985 issue of the *Astrophysical Journal*. Entitled "The M31 Globular Cluster System," and written by astronomers Crampton, Cowley, Schade, and Chayer, this paper contains much more information than the Hodge Atlas or Skiff's article. There are two major drawbacks to this paper, however. It is thick with technical jargon and contains no finder charts. Containing 509 objects identified as globular clusters, the paper does provide information on positions, magnitudes, and core radii. Also included is a general discussion about the globular cluster system and how they were identified. It also lists objects that in previous studies had been listed as globulars but have since been identified as starts. This paper is almost



Upper right: cluster G172. Upper left: clusters G150 (A) and G124 (B). Bottom left: cluster G250. Bottom right: clusters G213 (A) and G233 (B). Sketches by David Higgins with a 24-inch scope.

a requirement for anyone interested in observing M31's globulars.

The descriptions of the following globulars are relatively simple and straightforward. What I've tried to do is give you an idea of how bright or faint these objects appear through a 24-inch f/4 scope. How they will appear to you depends on the size of telescope you are using, the observing conditions, and your observing site. Also included in the descriptions are the cluster magnitudes and core diameters in arcseconds. You must keep several things in mind as you track these faint objects down. One item in particular is that the globulars along the periphery of the galaxy are a little easier to see than those nearer the center. Clusters in or near the core are very reddened by dust and gas.

It has often been said that regardless of the magnitudes quoted or information given on deep-sky objects, it is always a good idea to be a little skeptical of this data. There are so many variables in observing and published descriptions of deep-sky objects that the best advice for observers is simply do your own observing.

The M31 Globular Cluster System

G35. Magnitude 15.6, size 2.9".

Very faint with averted vision required. Fades in and out with the seeing. 9mm Nagler at 270x.

G87. Mag. 15.6, size 2.9".

Very faint with averted vision required for best view. 9mm Nagler at 270x.

G78. Mag. 14.3, size 3.2".

Bright and easily seen. Held steady with direct vision. This is the brightest globular of the group. In the same eyepiece failed with G70. 9mm Nagler at 270x.

G70. Mag. 16, size 2.3".

Extremely faint and difficult. Fades in and out with averted vision required. Same eyepice field with G78. 7mm Nagler at 348x.

G96. Mag. 15.5, size 2.7".

Even with a magnitude of 15.5, G96 was easily seen. Averted vision gave the best view. 9mm Nagler at 270x.

G119. Mag. 15, size 2.7".

Faint but held steady with direct vision. In the same eyepiece field with M31's companion galaxy M32. 9mm Nagler at 270x.

G134. Mag. 15.9, size 2.7".

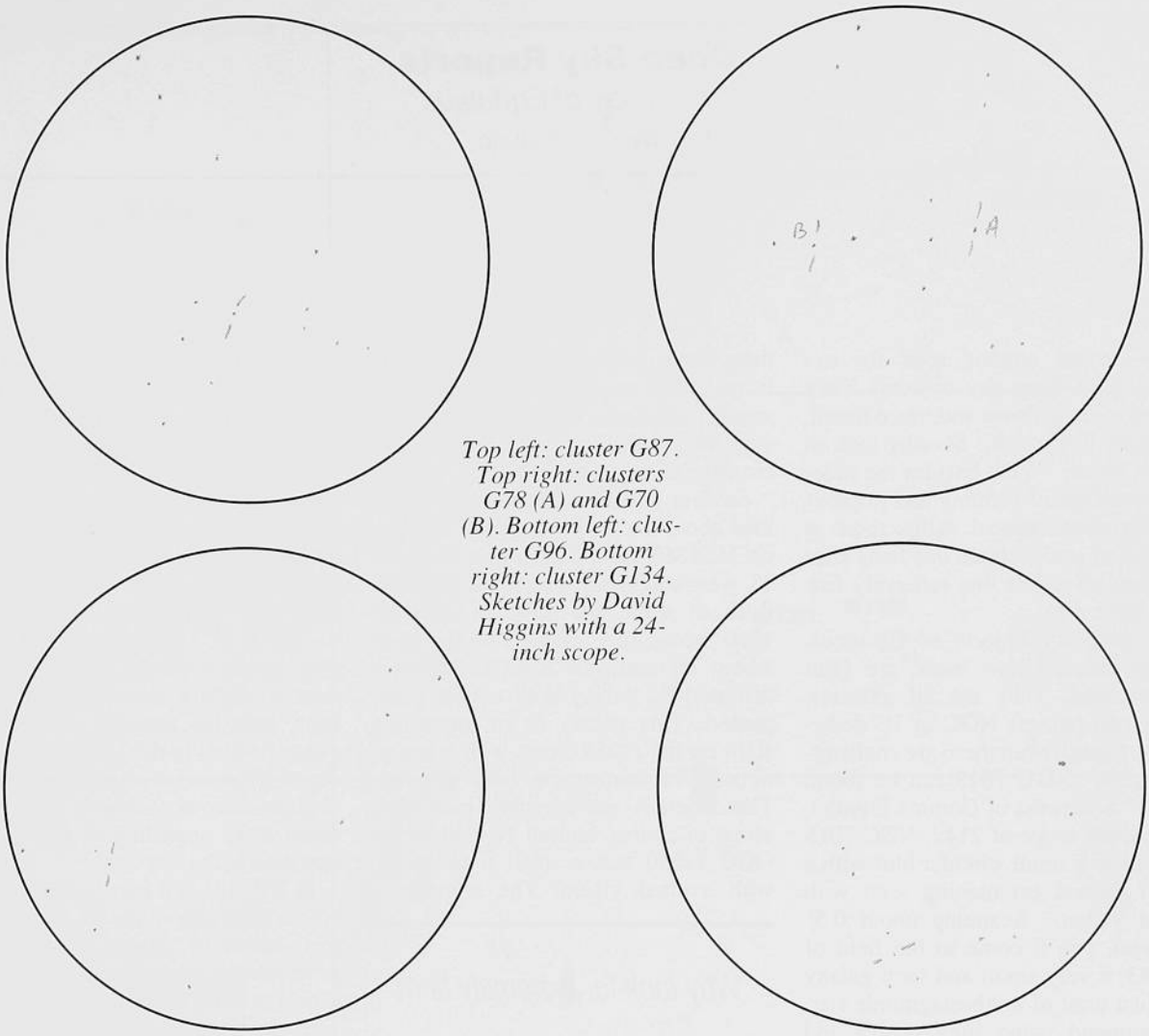
Faint with averted vision required for best views. Could be seen with direct vision when conditions permitted. 13mm Nagler at 187x.

G156. Mag. 15.6, size 2.5".

Faint with averted vision required. Held steady with direct vision when conditions permitted. In same eyepiece field with M32 and G176. 9mm Nagler at 270x.

G176. Mag. 16.3, size 2.7".

Extremely faint with averted vision required to even catch a glimpse of it. Bright star to the west has a tendency to wash it out. In same eyepiece field with M32 and G156. 7mm Nagler at 348x.



Top left: cluster G87. Top right: clusters G78 (A) and G70 (B). Bottom left: cluster G96. Bottom right: cluster G134. Sketches by David Higgins with a 24-inch scope.

G172. Mag. 15.2, size 2.4".
Very faint with averted vision required. Fades in and out with the seeing conditions. 9mm Nagler at 270x.
G150. Mag. 15.4, size 2.7".
Very faint with averted vision required. In same eyepiece field with G124. 9mm Nagler at 270x.
G124. Mag. 15.7, size 2.3".
Very faint and difficult with averted vision required. Fades in and out with seeing conditions. 9mm Nagler at 270x.
G250. Mag. 16, size 3.4".
Extremely faint with averted vision required to catch a glimpse of it. 13mm Nagler at 187x.
G213. Mag. 14.7, size 2.5".
Easily seen with direct vision. In the same eyepiece field with G233. 13mm Nagler at 187x.
G233. Mag. 15.4, size 2.6".
Faint and difficult. Averted vision required. In the same eyepiece field with G213. 13mm Nagler at 187x.
G234. Mag. 15.9, size 2.7".
Faint with averted vision required to see well. In the same eyepiece field with G263. 13mm Nagler at 187x.
G263. Mag. 15.5, size 2.5".
Faint with averted vision required to see well. In the same eyepiece field with G234. 13mm Nagler at 187x.
G244. Mag. 15.4, size 2.6".
Faint with averted vision required for best view. Fades in and out with the seeing conditions. In the same eyepiece field with G226. 9mm Nagler at 270x.
G226. Mag. 15.5, size 3.8".
The same as G244, faint with averted vision required. It also fades in and out with the changing conditions. 9mm Nagler at 270x.
G279. Mag. 15.4, size 4.9".
Although the largest in size of all of the globulars that I've observed, this cluster was very faint. Averted vision was required, and it suffers from fading in and out. 13mm Nagler at 187x.
G73. Mag. 15, size unknown.
I've included G73 although it is not associated with M31. It is a globular cluster in M31's companion galaxy NGC 205. 9mm Nagler at 270x.

Regardless of how many clusters you find or don't find keep in mind what you are seeing. Besides observing these clusters, spend some time studying the globular cluster system of our own galaxy and how it interacts with the Milky Way. By trying to understand the globulars in our own galaxy it will provide you with a much better appreciation of what you are seeing when you observe the clusters in M31.

David Higgins is the central coordinator of the National Deep Sky Observers Society, a contributing editor of this magazine, and frequently observes with large telescopes near his home in Krebs, Oklahoma.

Deep Sky Reports

A Survey of Equuleus

by Ernie Ostuno

Why would anyone look for extremely faint deep sky objects? They are hard to track down and, once found, don't look like much. So why look in the first place? Well, besides the practical advantage of refining and improving your observational skills, there is the sense of achievement one feels after observing an object that relatively few others have seen.

The deep-sky objects of Equuleus, like the constellation itself, are faint and obscured. They are all galaxies, and several possess NGC or IC designations, though even these are challenging targets. **NGC 7015** can be found about 1° northwest of Gamma Equulei. In a 13-inch scope at 214x, NGC 7015 appeared as a small, circular blur with a hint of central brightening seen with averted vision. Scanning about 0.5° northwest, you'll come to the field of **IC 5083**, a very small and faint galaxy lying just west of a 9th-magnitude star. I recommend using high power and averted vision on this one.

The same can be said of **ZWG 400.027**, which is two degrees due south of NGC 7015. In the 13-inch this galaxy showed up as a very small round patch of high surface brightness. About 1.5° east-southeast is **NGC 7040**, a small but somewhat brighter galaxy. The *RNGC* and *CGCG* mention a companion object close to the south, but this object appeared to be a faint star. There is another galaxy in the same low power field, however. **ZWG 401.006** can be found 10' southeast of NGC 7040. This was a tough one, only visible for brief moments using averted vision at 214x. Moving about 3° due north of here, you'll find a lone 7th-magnitude star.

A trio of faint galaxies like just to the south. **UGC 11697** is the most northerly of these, about 8' due south of the star. Moving about 10' further south brings you to **ZWG 426.015.** Both of these galaxies are very small and faint and required about ten minutes each of scrutiny with averted vision to reveal themselves in the 13-inch. **UGC 11700** is an easier target and can be found about 8' southeast of ZWG 426.015. A very faint star is in contact on the western edge of this galaxy.

Several faint IC galaxies are sprinkled about the southern part of Equuleus. **IC 1360** and **IC 1361** can be found 1° west-southwest of Alpha Equulei. Both of these are difficult, with IC 1360 being the brighter of the two. About 1° southwest is **UGC 11680**, a distorted Sc galaxy with a faint companion. This galaxy is an interesting sight on the *POSS* chart, with a bridge of material connecting both galaxies. These details are invisible in a telescope of course, and all I could see of UGC 11680 was a small round patch with averted vision. The companion may be visible with a large scope and high power, since it appears to have a high surface brightness on the Palomar photo.

Why look for extremely faint deep-sky objects? The sense of achievement one feels after observing an object that relatively few others have seen.

IC 1375 is a little more than 1° southeast of Alpha Equulei. This faint, compact galaxy has a very faint star almost in contact on its northern edge. One degree east-northeast, near the Pegasus border, is **IC 1377.** This little spiral showed up well with averted vision in the 13-inch, being one of the few galaxies in Equuleus that doesn't require eye strain to see.

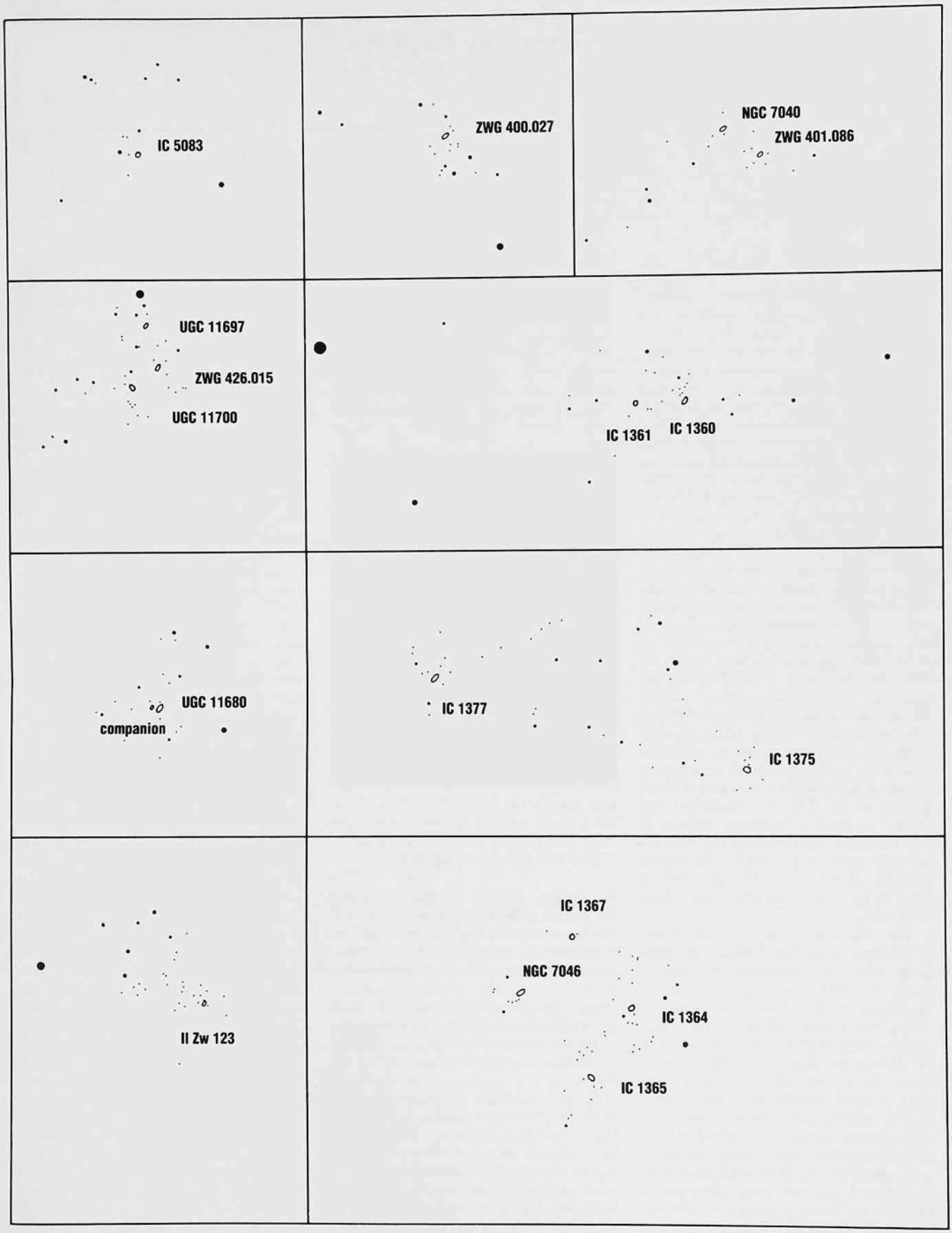
Brighter yet is **NGC 7046**, near the Aquarius border. At 214x, it was small oval, barely visible with direct vision. About 15' northeast is **IC 1367**, a very small galaxy with relatively high surface brightness. A star of about 12th-magnitude is close to the west. **IC 1364** is larger and brighter and can be found about 18' southwest of IC 1367, lying close to the northwest of a 9th-magnitude star. About 10' southeast of the star is **IC 1365**, a system of at least three galaxies whose combined brightness is slightly fainter than IC 1364. Both galaxies showed up well with averted vision in the 13-inch. The final object I'll mention is typical of all faint, obscure deep-sky objects in that it is much more appealing to the imagination than to the eye.

II ZW 123 is a faint compact galaxy with a 19th-magnitude BL Lacertae object almost in contact. Of interest to professional astronomers, the unusual object is quite challenging for the amateur. Its faintness and small size, combined with a faint star in contact made for a negative sighting in the 13-inch. Perhaps a well equipped reader out there can spot it.

The finder charts should help in locating and observing these galaxies. North is up in these drawings, in which the stars surrounding the galaxies were copied from photographs of each field and then checked at the eyepiece. Once you've found the correct field, use averted vision to make the galaxy appear.

There are of course other galaxies in Equuleus, but most are invisible outside of a large observatory. The above list should prove challenging enough. It should also prove that even the smallest, most obscure constellations hold quite a few deep-sky objects waiting to be seen.

Ernie Ostuno is an avid galaxy watcher living in Cheshire, Connecticut. His last article was "Galaxies along the Summer Milky Way," in the Summer issue.



Telescopic finder charts for Equuleus galaxies drawn by Ernie Ostuno. For rough locations of objects, find their positions in Sky Catalogue 2000.0 *and then consult* Uranometria 2000.0.

Deep Sky Reports

Observing Active Galactic Nuclei

by Bernard C. Abrams

For many years astronomers have concentrated their efforts on attempting to record the faintest details of galactic structure. Photographs produced for this purpose overexpose the cores of galaxies, hiding the stellar nuclei often seen in amateur observations. However, the relatively recent discovery of small angular diameta radio sources with peculiar optical counterparts has shifted the balance of importance. The wide implications of the quasar phenomenon have focused attention on the starlike cores of galaxies, believed to be the sites of some of the most energetic Focesses in the universe.

Prior to 1963 the work of Carl Seyfert had shown that the small central regions of some galaxies housed motions similar to those encountered in supemovae. In the 1950s newly discovered radio galaxies gave added interest to these active galactic nuclei (AGN). By 1963 the discovery of 3C 273 had begun to change astronomers' minds about the nature of quasars (QSOs). The technique of using lunar occultations allowed the positions of radio sources to be determined to an accuracy of one arcsecond; thus the optical counterpart of 3C 273 was identified and shown to have a spectrum similar to that obtained from other stellar markers of radio sources, but with a far higher redshift. Before 3C 273 such objects were thought to be peculiar stars within the Galaxy.

The situation today is that many QSOs have been found which are radio quiet, while the cosmological nature of quasar redshifts, challenged almost immediately in the 1960s, remains the subject of intense debate. Some observations suggest that quasars may not be as distant as their redshifts suggest. Many have been identified in groups only a small angular distance from a nearby galaxy with much lower redshift. Others appear to be linked to their neighbor galaxy by a bridge of luminous material. If such links, statistical or physical, are real, then some quasar redshifts definitely require a noncosmological explanation. There are quasars, however, that are seen to be associated in a similar way with clusters of galaxies having similar redshifts, so the situation is far from clear-cut.

Given that QSOs are as far away as their redshifts suggest, we are faced with the problem of accounting for their immense energy output. Variations in the luminosity of quasars place limits on the sizes of their energy sources, which somehow produce hundreds of times the energy of an entire galaxy from a region the size of the solar system. Present theories hold that the quasar generators involve a massive black hole siphoning material from the galactic core, using gravitational potential energy as the source of their power. If this is so, the black hole power source should switch itself off as it grows in size. Perhaps a large number of the galaxies we see today as relatively ordinary were once energetic quasars.

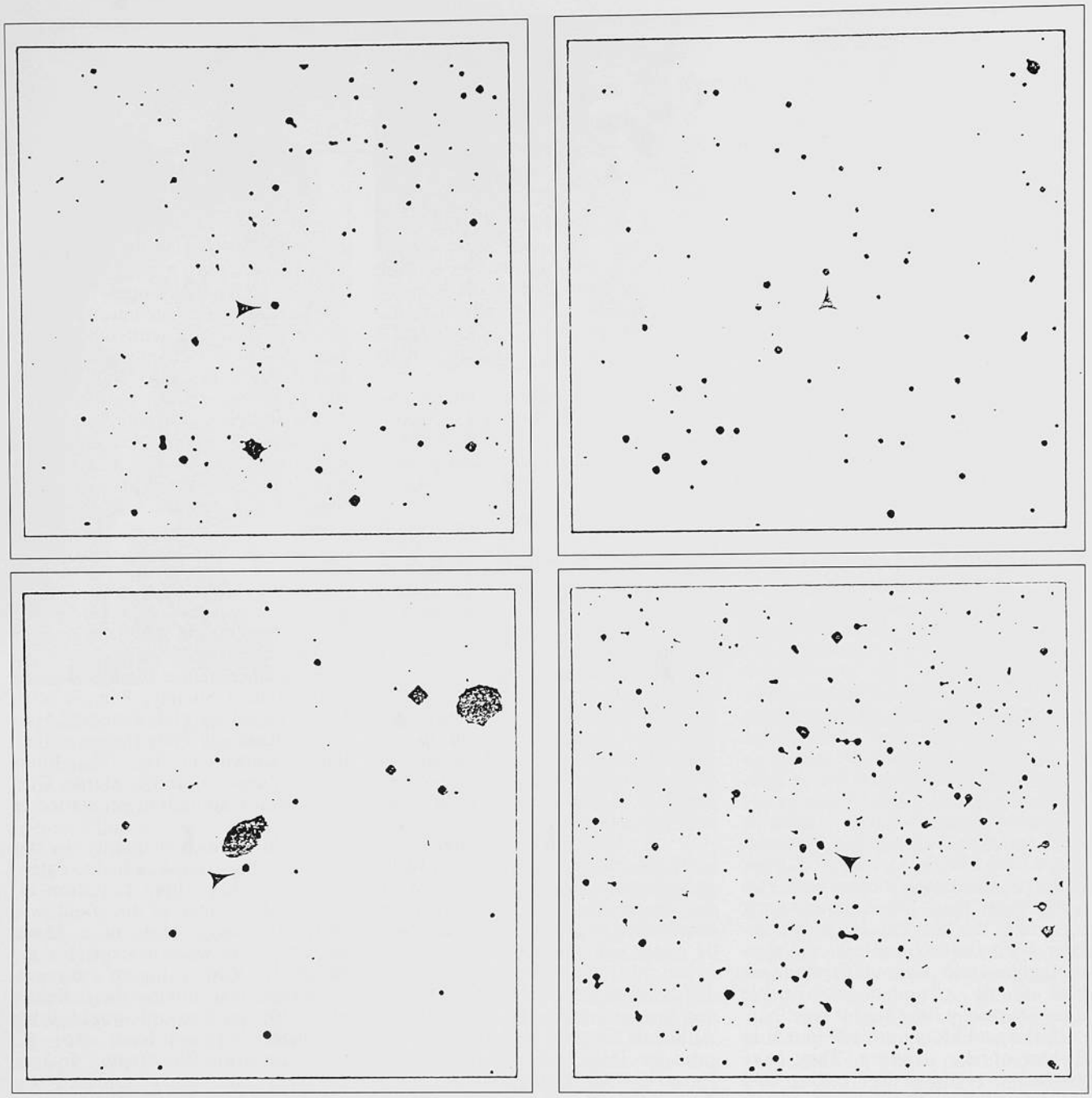
The remote BL Lac object OJ+287 is but a speck among brighter stars. Photo by Ron Arbour (16-inch f/5 reflector, TMAX 400 film, 5-minute exposure.

Seyfert galaxies, objects characterized by prominent bright nuclei with high- excitation emission line spectra, have already received mention as one aspect of the AGN phenomenon. Another variation comes in the form of BL Lacertae objects, named after the "variable star" in Lacerta shown to be coincident with a radio source. Similar to QSOs in some respects, BL Lac objects typically show a lack of strong emission features and more rapid variability. The former seems to be due to a lack of gas in the source ratha than a lack of ionizing photons, while the more variable luminosity can in some cases involve changes through five magnitudes or more. Although QSOs identified by radio generally show some optical variability, those objects purely optically selected tend to be more constant. In these cases and others the properties displayed can be accounted for within a model where a nonthermal source (the galactic nucleus) and a thermal source (the rest of the galaxy) make different contributions to the total emission.

There are a surprising number of areas in which amateur astronomers can contribute to the body of knowledge on AGNs. The position of some objects is known only to an accuracy of five arcseconds or so, and finder charts are required for others. The optical brightness of some stellar AGN in the magnitude 13 to 18 range is known only as an estimate. Variability in many objects requires thorough monitoring to allow more accurate characterization. Finally, such objects benefit from prolonged scrutiny to enable unusual bursts of activity to be monitored more closely. While searches continue to work toward the identification of new QSOs, with ever-increasing redshifts, there are grounds for seeking a more complete database for those objects that are already known.

It should be clear from the outline given earlier that many types of observations could usefully be made by amateurs with access to moderate-aperture telescopes. However, to derive maximum benefit from the work, close collaboration with professional astronomers is needed. In the United Kingdom, contacts with professional astronomers at Lancashire Polytechnic have led the nucleus of deep-sky photographers in the British Astronomical Association (BAA) to concentrate on the photographic monitoring of a number of quasars and BL Lac objects.

In order to simplify reduction, and to be of use to the professional community, collective observations need to be homogeneous as well as accurate. The method of observation should be cho-



Top left: finder chart for the peculiar objects PKS 1514-241, popularly known as AP Librae. Top right: finder chart for the BL Lacertae objects OJ+287. Bottom left: finder chart for the quasar Markarian 205, showing galaxy NGC 4319. Bottom right: finder chart for BL Lacertae itself. Finder charts courtesy Bernard C. Abrams.

sen to maximize the quality and quantity of data obtained, guided by consultation on suitable targets within instrumental and geographical limits. Working with BAA Deep Sky section directors Ron Arbour, Denis Buczynski, and Martin Ratcliffe, the author is currently producing finder charts for selected QSOs and BL Lac objects as part of a team effort by section members. Ultimately, standardized photographic procedures involving spectroscopic emulsions and densitometry will be used to monitor variability in these objects. In addition to the increased regularity of observation afforded by the project, it is hoped that some unusual phases of activity will come to light. To date, one such event has been recorded involving OJ 287, a BL Lac object in Cancer that has been found to vary between 13th and 16th magnitude. Periodic variations have been suggested on timescales varying from 40 minutes to 26 days. In February 1987, Ron Arbour was photographing OJ 287 for charting purposes using his 16-inch f/5 reflector. The images he obtained showed that the object was undergoing a fade, which reached approximately 16th magnitude.

The scope of amateur contributions in the field of AGN observation is evident. Photography seems to offer more than visual methods through as~ome~y or densitometry; the usefulness of visual estimates at the limiting magnitudes involved may be limited. And it may not be too long before we see amateur capability extending to photoelectric and spectroscopic work at these low light levels.

Bernard C. Abrams is a member of the British Astronomical Association.

Deep Sky Reports

Astrophotographers: The Next Generation

by Robert Reeves

Readers of popular astronomical publications have come to know many of the "old timers" in astrophotography. Names like Jack Newton and Martin Germano, among many others, have come to stand for high quality astrophotography. As the world wide interest in astronomy expands, it is only natural that other highly talented individuals enter the astrophotographic field. Names like Tony Hallas, Kim Zussman, Chris Schur, and many others, can now rightfully be called the "next generation" of top celestial photographers.

Tony Hallas and Daphne Mount

The newest team to gain national attention for their astrophoto efforts is California's Tony Hallas and Daphne Mount. While Tony is owner of a custom photo lab, he and Daphne have been active in astrophotography for only four years. In their young career, their celestial photography has been displayed on the covers of both ASTRONOMY and *Sky & Telescope*.

The 44-year-old Hallas is also an avid surfer and admits his first telescope, an 8-inch Meade SCT, was bout to check the ocean surf two miles from their home, not to look upward at the heavens. He adds however, "We are both professional photographers and wanted to find out how to do astrophotography. We were amazed at how hard it was!"

Hallas and Mount are self taught in the art of sky shooting. They have learned everything by reading and experimentation. They also credit fellow members of the Ventura County Astronomical Society Martin Germano and Kim Zussman for helping with advice.

Tony says he and Daphne hypersensitize their own film in a rig they made out of a stainless steel water filter and heat it with a large heating pad. He has also modified their Lumicon Easy Guider and fabricated a knife edge focuser to aid in astrophotography.

While they usually work as a team, Tony is now temporarily alone on Mt. Pinos while Daphne is completing school to be surgical registered nurse. Germano and Zussman often join Hallas on Pinos.

Lacking a permanent observatory, Hallas says he must assemble his equipment "with a grunt" every time he shoots. Each half of his Schaefer mount weighs 75 pounds. On that mount, Tony uses eight a C-14, a 10-inch f/6 Newtonian, or a 5-inch f/8 Starfire refractor.

To pursue his hobby, Hallas also admits that he "had to invest $500 in special clothing just to stay alive on Mt. Pinos in the *winter*." At an altitude of 8400 feet, the mountain air often cools to 10° F.

Hallas says he and Daphne usually photograph several times a month, but admits, "it's a real problem finding the time to do this in an already busy life, but it has also added another dimension to our intellect."

Tony advises beginners to read a lot and ask seasoned people lots of questions before buying equipment. He also cautions, "when astromania bites, one must be careful not to make it an obsession. I have been guilty of doing too much, too fast, too soon. I plan to take it a little easier in the future!"

K. Alexander Brownlee

In a field seemingly dominated by baby-boomers, K. Alexander Brownlee stands out as senior to other sky shooters in more ways than one. Now 71 years old, this Colorado amateur began his celestial photography in 1972 and has specialized in peculiar and interacting clusters and galaxies. Although his photos continue to appear in *Deep Sky*, Brownlee was forced to stop photographing the sky four years ago after major surgery. Today he is retired and enjoys classical music and opera.

While he was still active in astrophotography, Brownlee used a homemade 16-inch Newtonian with a Cave mirror. This apparatus was mounted in a 12-foot dome 100 feet from his home.

Brownlee had to make his own off-axis guider when he entered serious astrophotography and stuck out on his own, learning his skill "by trial and much error!" Like other serious sky shooters, Brownlee hypered his own film and did his own darkroom work.

"I am surprised how good celestial photos taken on Tech Pan can be," relates Brownlee. He ranks his shot of the double quasar 0967+561 as his best astrophoto.

Kim Zussman

The desire to create celestial images he could share with others lured Kim Zussman to begin astrophotography five years ago. This 34-year-old periodontist from southern California started in astronomy 25 years ago with a 6-inch f/4 Newtonian. Today Kim is widely known for his outstanding deep-sky photos taken through his modified Celestron-11 scope.

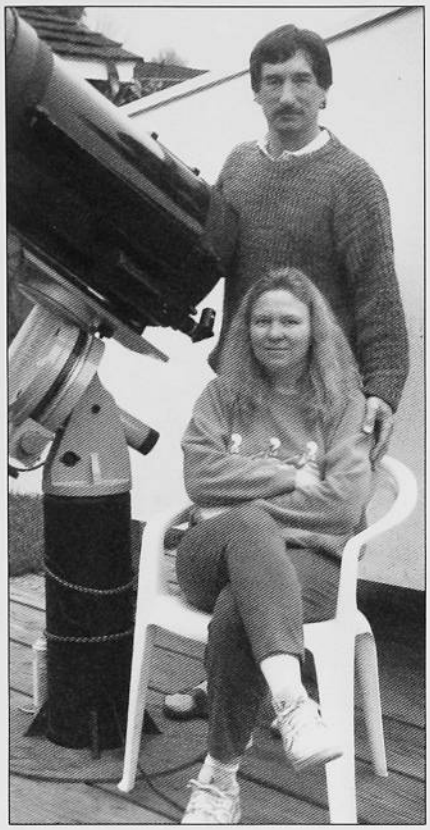
Zussman travels to Mt. Pinos, about a two hour drive, once or twice a month to make high resolution exposures of galaxies. Kim uses portable equipment and must set up from scratch each time he shoots.

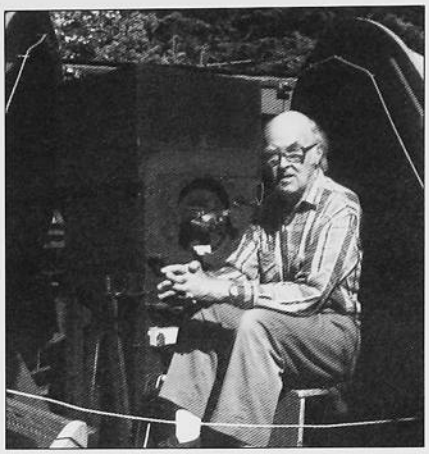
A member of the Ventura County Astronomical Society, Kim is often joined by fellow club members Martin Germano and Tony Hallas, collectively known as the "Mt. Pinos gang." Zussman credits Martin Germano with helping him get started in sky shooting.

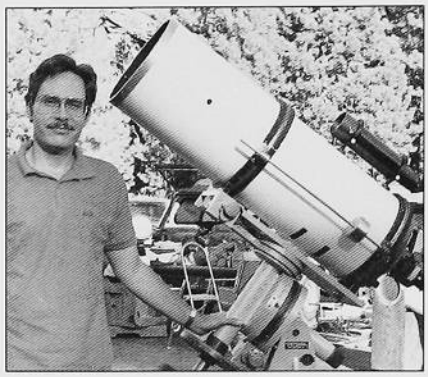
To achieve his high quality sky images, Zussman found he had to extensively modify his Celestron-11. "While the center of the field was sharp, the outer edges of a 35mm camera frame were too soft for my standards. Ray tracing on a computer showed that moving the corrector plate 307mm forward would bring the image into sharp focus across the entire camera's film frame." In fact, Zussman completely replaced the corrector plate on his Celestron-11 and maintains the correct placement of the secondary mirror by mounting it on Cassegrain secondary mirror. Kim ranks his telescope's modifications as his crowning achievement in astronomy.

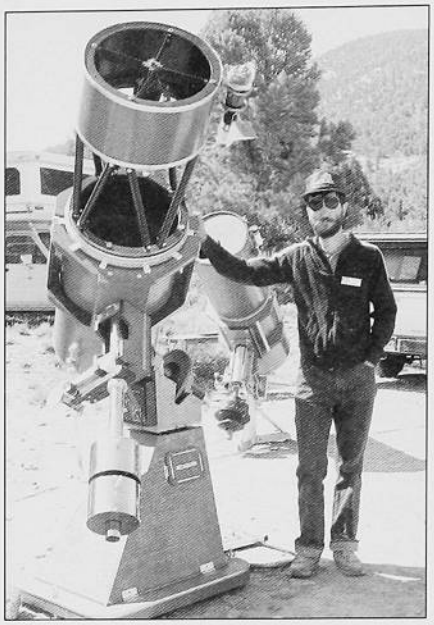
Another equipment modification Zussman found essential was a heated control paddle for his drive corrector. In the winter chill of Mt. Pinos, Kim holds a heated hand controller in an insulated bag to help him keep warm. Like most other experienced astrophotographers, Kim hypers his own film in homemade equipment and does his own darkroom work.

Zussman is planning to upgrade his equipment to a 14.5-inch f/8 Cas-









Far left: Tony Hallas and Daphne Mount. Top center: K. Alexander Brownlee. Bottom center: Kim Zussman. Above: Chris Schur. Photos courtesy Tony Hallas, K. Alexander Brownlee, Kim Zussman, and Chris Schur.

segrain in a year and looks forward to inexpensive CCD equipment.

Summing up his astrophoto efforts, Kim admits "it's not the photography that's exciting, but the objects themselves. This closeness to the universe has greatly improved my life. It is excellent stress reduction therapy!"

Chris Schur

Arizona's Chris Schur leaves no doubt about his dedication to astronomy when he states, "I live for astronomy. There is more film in the fridge than food. There are more telescopes in the living room than furniture. The license plate on our truck reads COMETS. What more can I say?"

Schur is a 31-year-old electrical engineer whose interests include photography, sports cars, and house building. He began developing an interest in astronomy at age 10. Schur initiated his astrophoto career by recording Comet Kohoutek in 1973. Taking the astrophoto plunge with a tripod mounted 35mm camera and Tri-X film, Schur braved knee-deep snow only to have the shutter on his Pentax freeze open in the -20° F cold.

Graduating to small refractors and a 4.5-inch equatorial reflector at age 15, Schur began to learn the intricacies of astrophotography. "This is where I learned about focus, flexure, and all the really pleasant gremlins waiting to ruin 90 percent of your shots," says Schur. He currently photographs emission nebulae and comets with his homemade 16-inch f/4.5 Newtonian and an 8-inch Schmidt camera. He averages four to six photo sessions per month.

While Schur plans to mount the 16-inch scope in a dome at his house, he currently transports the 8-inch Schmidt camera up to 8,000 feet in the mountains 100 miles north of home.

Schur's wife Dawn often joins him on astronomical expeditions and uses her newly built 8-inch Dobsonian. Schur credits Dawn with "pushing me toward excellence in my work. She has always been a real critic when it comes to the quality of my astrophotos."

"The thing that excites me about astrophotography is the chance to make a real discovery," says Schur. "To be able to share my finding with my friends is more of a high than anything else."

Currently a member of the Saguaro Astronomy Club in Phoenix, Chris credits fellow Arizonan Pierre Schwaar with having the greatest influence on his astronomical career. Chris says, "He nursed me through some real tough times as I built my 16-inch."

Despite his recognized success, Chris does admit to the usual photo bloopers all experienced sky shooters accumulate. "My most embarrassing astrophoto? How about the one hour shot of the Lagoon with no film in the camera?" When asked about what kind of astronomical equipment he would like to get in the future, Chris replies "how about a 14-inch Schmidt or an 8-inch Alvan Clark?" Then he jokingly adds, "how about staying married?"

Schur says that his involvement in astronomy has brought him great rewards. "People just don't know what they are missing," says Schur. Astronomy has improved my life a thousandfold. I have met hundreds of people and accomplished something, and have shared many happy moments with good friends."

This new generation of nationally known sky shooters started with simple equipment and climbed the astrophotography learning curve. The photographers had access to the same sky we all do. They use the same equipment available to all others who are dedicated to the art of celestial photography. By following in their footsteps someday you may also be in the "next generation" of nationally recognized astrophotographers.

Robert Reeves, himself one of the nation's leading astrophotographers, writes frequently for Deep Sky *and* ASTRONOMY.

Deep Sky Reports

Pease 1: The Planetary in M15

by Alister Ling

It was one of those nights. A cold front had swept the hot summer haze away. We spotted the supernova in M58, and the waxing gibbous Moon finally set. We were hungry for the real deep-sky.

My observing buddy Jerry Spevak suggested we try for the planetary in the bright globular cluster M15 since the cluster was rising to the meridian. Although we were only 3/4 of an hour's drive from the blazing lights of Toronto, the North York 12.5-inch Newtonian with very fine optics could reach 15th-magnitude stars (but not galaxies) under a Full Moon. Maybe Pease 1 was possible, after all.

We got out the finder chart, cranked up the power to 400x, and stared at the countless stars pouring out of the globular's center. Jerry and I traded places quite a number of times, taking turns at the eyepiece and finder chart, trying desperately to grasp some recognizable star pattern.

Eventually I spotted the trapezium on the northwest side, about one core diameter away from Pease 1. Once we confirmed this, it would be a simple matter to star hop our way to the planetary. Wrong! Minutes flew by as we had the greatest difficulty recognizing further patterns.

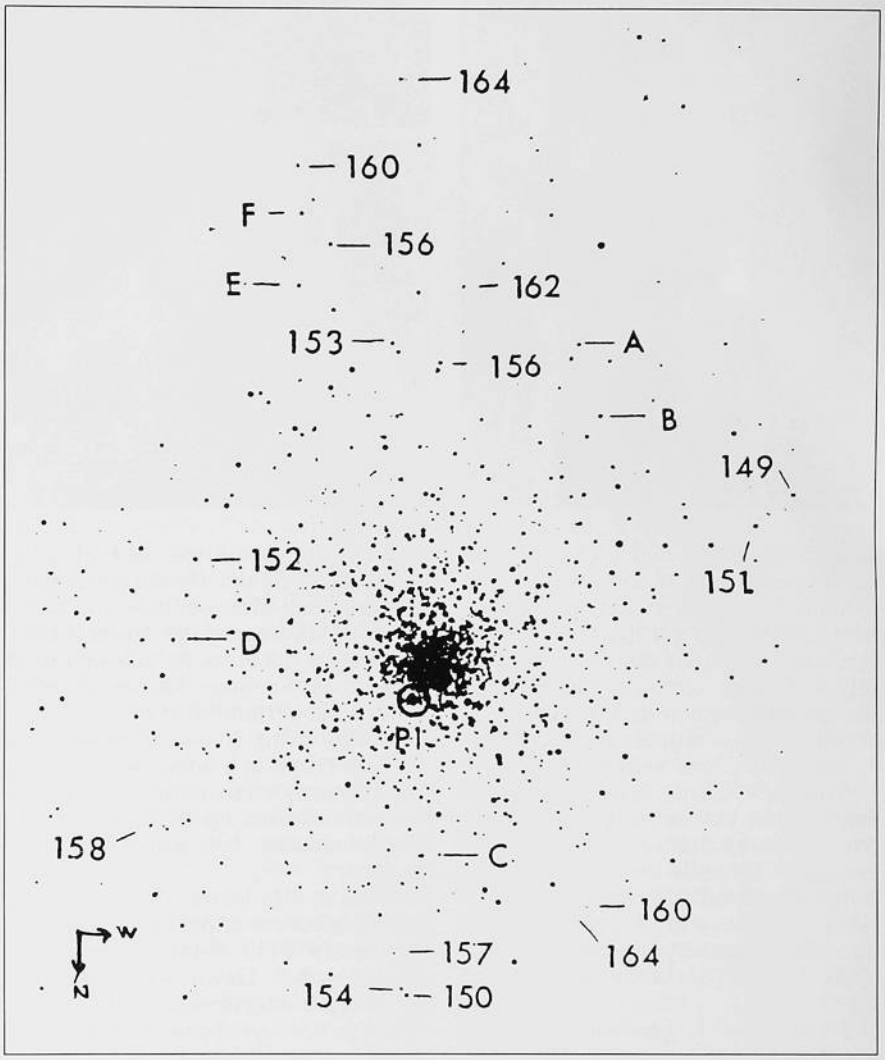
With a flash of insight, we figured out that the finder chart was inverted. Stars fell into place as we shone the flashlight through the paper. Seconds later we were on the position of the planetary. According to the chart, it was involved in the easternmost of three clumps in a line.

Locating the position of an object is one thing, but identifying it as a tiny planetary nebula is another matter. Hiding in a clump of stars, the nebula could not be resolved.

We reached for our primary tool of the trade — an O III filter. Blinking most planetaries at low power is a snap. Flicking a filter back and forth between the eye and eyepiece at 400x when the exit pupil and eye relief are small is one mean feat.

We fell back on the comparison method. With the filter in place and a dark cloth over the head to shield the eye from stray light, we could see a brighter dot where the clump used to be. The other clump just to the west remained a faint blob. Confirmation at last!

It is instructive to realize that the entire hunt sequence took about two and a half hours. The dark cloth was crucial to keeping the eye dark adapted enough to get a critical focus on the stars which are dimmed by two to three magnitudes through the O III filter. The lack of a clock drive would have made the observation an experiment in frustration. As a final comment, I would like to mention that observing in a group of two or three people is often very rewarding, because you can egg each other on to look for so-called impossible objects. Observing alone, one can be easily discouraged after a few minutes of blank starfields.



Finder chart for the planetary nebula Pease 1 inside globular cluster M15. North is at bottom, west at right. Courtesy Alister Ling. Opposite page: M15 photographed with a 10-inch f/5 reflector, 103a-O film, and a 10-minute exposure. Photo by Lee C. Coombs.

Alister Ling is an experienced observer and writes this magazine's "Small Scope Showcase" column.

Deep Sky Reports

Reader's Page

by Steve Coe

This issue's column will clean up a bunch of really superb reader observations we have received and simply didn't have room to publish before this. I am very excited by the high response this column has generated and expect that soon we'll be able to convince Dave to commit more space to the column. So, without further ado, here are the best of your recent observations...

Tom Polakis, Tempe, Arizona: I observed a group of galaxies in Leo with a 13.1-inch reflector and would like to share the observations with readers.

NGC 2903: At 115x this galaxy has a bar-shaped central region elongated east-west, and hints of spiral arms extending from the bar. A 14th-magnitude star lies near the end of one arm.

NGC 3185 is a featureless, round glow of even surface brightness. It is pretty faint and just about average in size. It is one galaxy in the beautiful NGC 3190 galaxy group, which also includes NGC 3190, NGC 3187, and NGC 3193.

NGC 3190, the brightest in the group, has an edge-on appearance. It is elongated at least 2:1 and has a stellar nucleus.

Dennis E. Hoverter, Mechanicsburg, Pennsylvania: I used an 8-inch f/4.5 reflector to view *M56*, the great globular cluster in Lyra. At 150x I saw a nearly circular glow with no central brightening and a fainter, outer glow that encircles the cluster.

I used a 13.1-inch f/4.5 reflector to view the open cluster *NGC 752* in Andromeda. The resulting sketch shows a loose, scattered cluster that demands a wide field eyepiece.

Bob Buchheim, Long Beach, California: I used my 13.1-inch reflector at the Orange County Astronomers' Anza Observing Site.

NGC 7662 appeared like a perfectly circular, tiny, and very bright planetary nebula. It seemed quite smooth, except for the tiny central "hole" that was barely visible at 100x. Going to 250x didn't add any detail.

NGC 404 was nice and bright, surprisingly easy to spot at 50x, despite the glare from Beta Andromedae. I sketched it at 100x, and could just see a hint of what looked like spiral structure at the galaxy's edges.

NGC 7686 was a very sparse open cluster — barely more than a half-dozen stars clearly visible against a faint background glow. The bright star in the field has a nice orange-red color. The second brightest star, southwest of the cluster, is a contrasting light blue.

NGC 752 is a huge cluster, very much like the Beehive. The group of bright, bluish stars (7th and 8th magnitude) overfilled my 50x field of view, so I tried 7x50 binoculars, which gave me a nice impression of the cluster. A comparable haze of stars just west of the main cluster made it appear like either two separate groups, or else a single, large group with a wide, linear, dark gap across its waist.

And where is *NGC 68?* I couldn't find any evidence of it!

Mark Green, Terre Haute, Indiana: In anticipation of future Steve Coe articles, I enclose a sketch of the NGC 68 galaxy group. I took advantage of a few clear evenings in December and January to study this group. I used a 17.5-inch f/4.5 reflector at 160x. The visual limiting magnitude was 5.5; the telescopic limiting magnitude was 15.5.

The NGC 68 galaxy group: This is a very easy group to overlook with low power under less than perfect skies. After having found the location, I switched to 160x. While all of the individual group members were little more than faint, hazy patches, I could identify three of the patches using the sketch in the Webb Society handbook. The galaxies were NGC 68, NGC 70, and NGC 71. Of these, NGC 70 appeared to be the brightest. Given its catalog magnitude of 15.5, it may have appeared bright because it is large and apparently is associated with a field star along its northern edge. NGC 72 appeared to be the second largest member; while fainter than the three brightest members, it was visible with direct vision. NGC 69 was considerably fainter and at the limit of direct viewing. It was occasionally visible with averted vision.

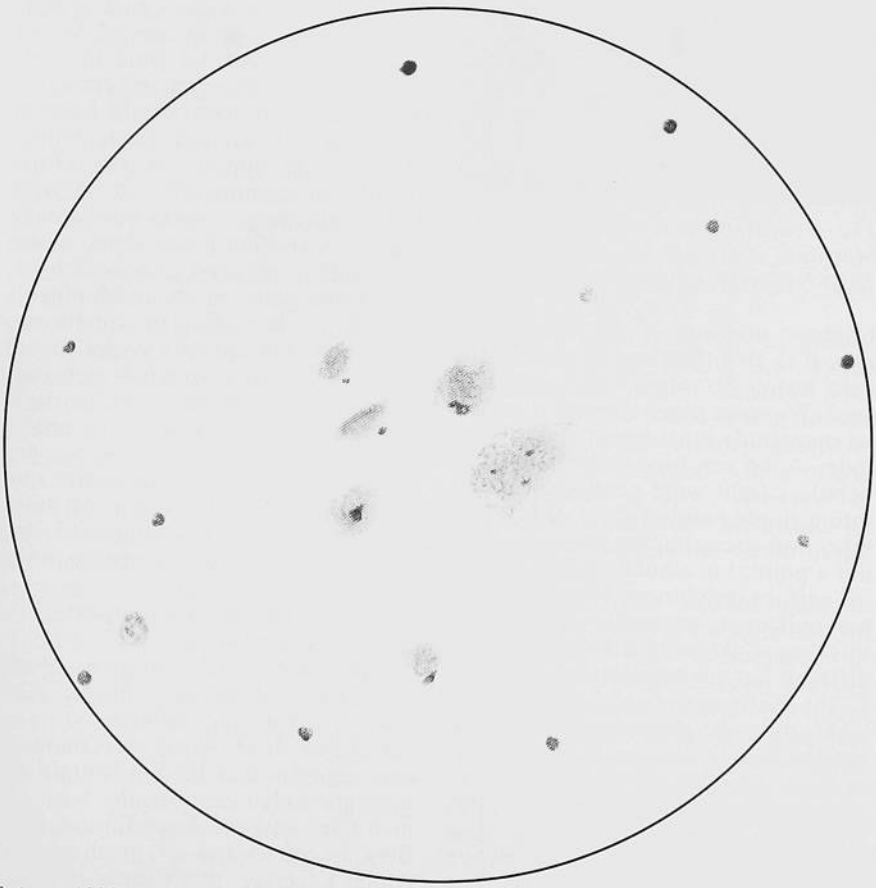
Brent Archinal, U.S. Naval Observatory, Washington, D.C.: I am sending a group of observations of galaxies in Leo that may be of use for your Reader's Page.

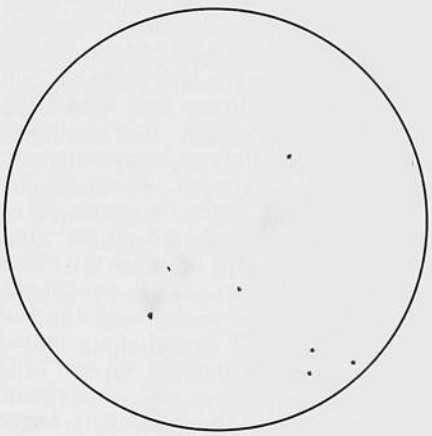
NGC 2903: With the 32-inch telescope at Perkins Observatory in Delaware, Ohio, this galaxy is a very nice, very bright spiral. It shows as a thin line with a nucleus in its center by direct vision, and appears as a fairly open spiral with averted vision. There is a possible nebulous object nearby that is found to be a double star on the *POSS*. I also looked for NGC 2905 nearby but was not sure of its position. Later I found that NGC 2905 is listed in the *RNGC* as being the same object as NGC 2903.

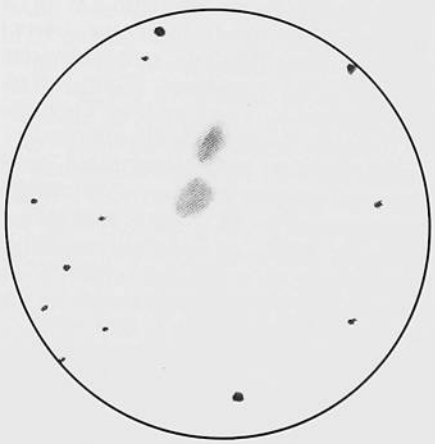
The NGC 3190 galaxy group: Again using the 32-inch scope at low power I sketched the group. NGC 3190 is the small edge-on galaxy at center. It appears slightly brighter on its northern side and is about 4' by 1' in size. NGC 3193 is the roughly circular, 1'-diameter galaxy to the north. It is fairly bright as well, appearing as an elliptical galaxy. NGC 3185 is faint and extended, about 5' by 4' in extent. NGC 3187 is very faint, visible only by averted vision.

Next time, we'll concentrate on observations of Auriga, including NGC 1664, NGC 1857, NGC 1907, NGC 1893, IC 410, and IC 2149. In the spring issue we'll look at Coma Berenices, including NGC 4565, NGC 4340, NGC 4350, the Coma galaxy cluster, and the Coma Berenices star cluster. Happy observing!

Left: NGC 404 and Beta Andromedae sketched by Bob Buchheim using a 13.1-inch reflector at 100x. Bottom left: The NGC 68 group sketched by Steve Coe using a 13.1-inch f/5.6 reflector at 135x. Below: The NGC 3190 galaxy group sketched by Brent Archinal using the 32-inch reflector at Perkins Observatory in Delaware, Ohio, at low power. Below center: The NGC 68 galaxy group sketched by Mark Green with a 17.5-inch reflector at 160x. Bottom: Galaxies NGC 3226 and NGC 3227 sketched by Brent Archinal with the 32-inch Perkins scope at low power.







Deep Sky Reports

Autumn's Challenging Deep-Sky Objects

by Phil Harrington

Though the memory of warm summer nights is still fresh in our minds, there is no denying that the change in seasons is upon us. The summer sky, rich in clusters and nebulae, is now being replaced with the galaxy-strewn skies of autumn. Here we find objects aplenty to test our observational skills and techniques. The following menu offers just a few samples of what this season has cooked up for us. Try your luck with some of these morsels, and then branch out on your own to come up with your own list of autumn's tempting treats.

A Naked Eye Challenge: M33 in Triangulum

Stats: R.A. 1h33.9m Dec. +30°39' Constellation: Triangulum Magnitude: 6.5 Size: 62'x39' Sc galaxy

Our naked eye entry was suggested by Springfield, Massachusetts amateur Jack Megas. M33, the Great Spiral Galaxy in Triangulum, is considered by many to be the ultimate test of an autumn night's transparency. Infamous for its low surface brightness, many an amateur has spent long hours searching for it to no avail.

I fondly recall my first naked eye encounter with M33. It was during the 1974 Stellafane convention in Springfield, Vermont. There in the early morning hours, a group of us had informally gathered on the summit of Breezy Hill to enjoy the beauty of the seasonal sky. It was an exceptionally clear night, with the full 3° span of M31 visually accounted for. A few of us thought we saw M33 nearby; the others were convinced we were crazy. As the debate began to heat up, who should meander by but Walter Scott Houston. With a certain inflection in his voice, he remarked that "M33 is quite obvious tonight" and wondered if any of us had spotted it. The doubting Thomas' in the crowd were quickly silenced!

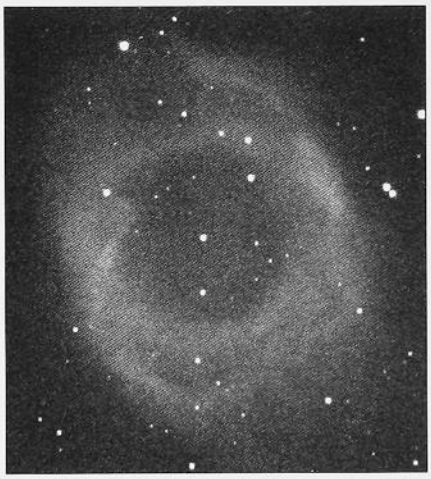
On the next crystalline night, perhaps before you begin your telescopic survey of the sky, pause and take a look for M33. At 2.3 million light-years away, it is the most distant object visible without optical aid.

Giant Binoculars, 2- to 3-inch Telescopes: The Helical Nebula

Stats: R.A. 22h29.6m Dec. -20° 48' Con.: Aquarius Mag.: 6.0 Size: 15' Planetary nebula

Judging by its statistics, NGC 7293 (the Helical Nebula) sounds as though it should be the easiest planetary nebula in the sky to find. Imagine a planetary nebula near the naked-eye limit and measuring half the size of the Full Moon. It should practically tap you on the shoulder and say "here I am." But when you aim your scope toward its location and gaze into the eyepiece, it's often not there.

The problem is that statistics do not tell the whole story of the Helix Nebula. NGC 7293 is, in fact, the



The Helical Nebula photographed by Martin C. Germano (8-inch f/10 SCT, 103a-F film, 90-minute exposure.

brightest and largest planetary in the sky. It is also the closest, at 100 parsecs away. So why is it so hard to see? We must remmeber that the listed magnitude is its integrated magnitude — the resulting magnitude if te nebula's light were condensed down into a single point of light. When you take into account that the nebula is not a point, but actually 0.25° across, its surface brightness (or brightness per unit area) plummets. That turns this "easy" target into a difficult test; difficult but not impossible.

The Helix proves to be a pleasant sight through giant binoculars and richest-field telescopes. Larger, longer focal length instruments may reveal cloud structure and the 13th-magnitude central star, but their view is less attractive due to the restrictive field of higher magnification. The most aesthetically pleasing encounter I have had with the Helix was through 11x80 binoculars. Its gray disk was clearly visible against a starry field. The central "hole" also stood out well in this unfiltered view (curiously, a nebula filter seemed to do little to improve the image). Telescopic observers will do best by equipping their instruments with the widest-field eyepiece at their disposal. After some careful searching, perhaps with averted vision at first, the Helix ought to come clean.

4- to 6-inch Telescopes: NGC 604

Stats: R.A. 01h33.9m Dec. +30° 39' Con.: Triangulum Magnitude: 9 Size: 2'x1' Emission nebula

As previously noted, many observers regard M33 in Triangulum as one of the most difficult objects to find in the autumn sky. So it may come as a surprise to find out that a few of M33's own galactic objects can be found in smaller telescopes.

NGC 604 is a huge region of ionized hydrogen within one of M33's spiral arms, about 11' from the galaxy's nucleus. We can only imagine the sight an observer would have of NGC 604 if viewed from within M33. While similar to the Orion Nebula in composition, it is over 1,000 times larger. From our vantage point 2.3 million light years away, NGC 604 is reduced to only 2' by 1' across and glows at about 9th magnitude. Still, depending on conditions, NGC 604 is frequently easier to see than M33 itself. Through 4- to 6-inch instruments, it appears as an oval smudge of light with a distinctly brighter nucleus. Larger telescopes should be able to split its center into two separate starlike points. An associated cluster of magnitude 15 and fainter stars may just be visible in the largest backyard scopes.

8- to 10-inch Telescopes: Planetary IC 5217

Stats: R.A. 22h23.9m Dec. +50° 58' Con.: Lacerta Mag.: 12.6 Size: 6" Planetary nebula

Cal Powell of Westport, Connecticut, suggests that IC 5217 might offer a good challenge for the 8- to 10-inch telescope set. Found 2° south of Beta Lacertae and 2° northwest of Alpha Lacertae, this nebula is effec-

Galaxy M33 photographed by Matin C. Germano (8-inch f/10 SCT, 103a-F film, 90-minute exposure).

tively masked by the bright stream of the Milky Way and will probably require some hunting. My notes made with an 8-inch f/7 Newtonian at 150x recall a small, slightly oval, grayish disk with a major axis stretching north-south. The central star was nowhere to be found, which really should come as no surprise since it is listed as magnitude 15.6. Perhaps observers with 12-inch or larger instruments will have better luck. Recent studies show that IC 5217 lies 3.2 kiloparsecs away.

12- to 14-inch Telescopes: NGC 1343

Stats: R.A. 03h32.4m Dec. +72° 24′ Con.: Cassiopeia Mag.: 14.1 Size: 3′x2′ Peculiar galaxy

NGC 1343 is a little known and little observed galaxy located in the extreme northeastern corner of Cassiopeia. Though it has been recorded in smaller instruments, a 12- to 14-inch scope is usually required for positive identification. With higher power eyepieces in place, telescopes of this size reveal a small, diffuse glow with a faint stellar nucleus.

Long exposure photographs reveal NGC 1343 is a peculiar galaxy dominated by a ring encircling the galactic core. It has been suggested that this odd ring feature results when a smaller object penetrates a larger body (in this case, the galaxy). When the path of collision strikes nearly perpendicular to the plane of the larger galaxy, tidal forces generate the observed ring. To illustrate this, imagine dropping a small stone into a pond. As the stone strikes the water, concentric ring-like waves are sent rippling away from the point of impact.

More observations of ring galaxies are needed to either solidify or debunk this theory. In the meantime, NGC 1343 remains a most unusual object to challenge the amateur.

16-inch and Larger Telescopes: The NGC 48 Galaxy Group

IC 1534 Stats: R.A. 0h13.8m Dec. +48°09′ Con.: Andromeda Mag.: ? Size: ? Galaxy

NGC 48 Stats: R.A. 0h14.0m Dec. +48°14′ Con.: Andromeda Mag.: 15p Size: 1.7′ Galaxy

IC 1535 Stats: R.A. 0h14.0m Dec. +48°09′ Con.: Andromeda Mag.: ? Size: ? Galaxy

IC 1536 Stats: R.A. 0h14.2m Dec. +48°08′ Con.: Andromeda Mag.: 15p Size: 0.7′ Galaxy

NGC 49 Stats: R.A. 0h14.3m Dec. +48°14′ Con.: Andromeda Mag.: 15p Size: ? Galaxy

NGC 51 Stats: R.A. 0h14.6m Dec. +48°15′ Con.: Andromeda Mag.: 15p Size: 1.8′ Galaxy

There are many dozens of galaxy groups scattered around the sky to challenge the largest amateur telescopes. Of those found at this time of year, the 136-million-light-year-distant NGC 48 group is one of the most difficult to spy. Observers at mid-northern latitudes will find its six galaxies close to the zenith in the early evening.

To locate this distant galactic swarm, first center your attention on 5th-magnitude 22 Andromedae in north-central Andromeda. By moving 2° north-northeast, you should come upon an optical double star with 5th- and 6th-magnitude components. From here, you are only arcminutes away from our target, as the galaxies lie about a degree to the stars' east.

Although NGC 48 is catalogued at photographic magnitude 15 (relatively bright for a large scope), it remains difficult to spot due to its low surface brightness. Classified as an S(B) pec barred spiral, it is seen as a faint stellar core engulfed in an even dimmer galactic halo.

NGC 48 is the westernmost in a string of three galaxies. Lying 0.25° to the east is NGC 49. Appearing a small, slightly oval smudge, its dim stellar nucleus may be detected with averted vision on exceptional nights. The easternmost member in this string of three is NGC 51. Most observers will find this to be the brightest and easiest to spot, although it also shines at photographic magnitude 15. Its slightly oval disk is punctuated by a brighter central core, making it possible to glimpse NGC 51 through 10-inch telescopes under extraordinary conditions.

The other three galaxies in the group, unplotted on any popular star atlas, all lie at the very threshold of visibility in amateur instruments. IC 1534 is seen only as an extremely faint glow about 5' southwest of NGC 48. Careful scrutiny through high power might show its tiny disk brightening to a central hub. A faint star lies just northeast of IC 1534, with IC 1535 trailing close behind. This apparently coreless galaxy is larger and fainter than IC 1534, making it a difficult test indeed. The final galaxy here is IC 1536, located between two faint stars. Once again, a miniscule smudge is all that awaits the backyard observer.

Phil Harrington's book on observing with binoculars will be published this autumn by John Wiley & Sons.

Deep Sky Reviews

A Universe of Words

by Mark J. Coco

Observing Handbook and Catalog of Deep Sky Objects by Christian B. Luginbuhl and Brian A. Skiff. 350 pp., hardcover, $49.50. Cambridge University Press, New York, 1990. (ISBN 0-521-25665-8.)

The *Observing Handbook and Catalog of Deep Sky Objects* is a welcome addition to the literature of amateur astronomy. The work is a combination handbook and catalog that stands alone as a comprehensive guide for the deep-sky observer.

The book begins with a short introduction to telescope optics, eyepieces, finderscopes, star atlases, and observing techniques. Although these sections are relatively short, they cover details often overlooked in general observing guides.

The handbook, which comprises the majority of the book, contains descriptions of some 2,050 objects viewed through several different telescopes, many of which are commonly used by amateur astronomers. The book covers 68 constellations (all north of -50° declination) and is arranged in alphabetical order by constellation, which makes the book very easy to use as a reference. Within each constellation the objects are arranged by NGC number (objects without NGC numbers are placed in right ascension order).

Each entry begins with an abbreviation indicating object type (i.e., open cluster, galaxy, etc.), followed by the catalog number. After this, the header information changes depending on the object type. Galaxies include dimensions, integrated magnitudes, and surface brightness. Open clusters contain diameters, integrated magnitudes and estimated numbers of members. All header abbreviations are explained in the introduction.

The descriptions are in text form (no abbreviations except for directions) and indicate the object's appearance through the telescopes the authors used. The description also mentions bright stars in the field and Messier numbers (if applicable).

Luginbuhl and Skiff verified their visual observations by examining photographs made by professional astronomers and reading descriptions from other handbooks and catalogs. Not a detail was missed.

I was impressed by the thoroughness in this book. Descriptions go beyond the usual easy observations and challenge the reader to make more meticulous observations. The description of the Andromeda Galaxy highlights numerous features within the galaxy itself.

The book also contains a few photographs and drawings of some of the objects described in the text. The photographs are clearly labelled with object designations and directions. The drawings are excellent, but too few in number. Although all drawings indicate north, only two show east (or west). The reader is left to guess east or west, which for drawings made with Newtonians is not a problem since they produce inverted images. However, image orientation in refractors and Cassegrain reflectors varies depending on whether viewing straight-through or with a diagonal prism. Unfortunately, readers are never told how the drawings were made, either in the caption or introduction.

The handbook is followed by an excellent bibliography. In addition to listing book titles, the authors indicate the strong points of each. Some of the descriptions and recommendations repeat from introductory sections, where the authors describe the books they used to assist them in researching the *Observing Handbook and Catalogue of Deep Sky Objects*.

The book concludes with a catalog that contains 2,828 deep sky objects, all of those listed in the handbook plus a few additions. A list of double stars, not mentioned in the handbook, is included to assist in rating the seeing conditions. I was happy to see that all coordinates are listed in equinox 2000.0 *and* 1950.0 .

This book is a favorable addition to any amateur's library, and an invaluable must for any deep-sky observer.

The Deep Space Field Plan by John C. Vickers. 267 pp., paper, $24.95. Sky Publishing Corp., Cambridge, Massachusetts, 1989. (ISBN 0-933346-59-X.)

Have you ever looked through the NGC catalog and wondered what some of the objects look like simply by reading the descriptions? If so, you are not alone. Such an activity has been the motivating force that has launched many an observing program. But take the idea one step further, to photography. The results of such an endeavor is recorded in John Vickers' *The Deep Space Field Plan*, more commonly referred to as *The Plan*.

The heart of *The Plan* is the list of 682 objects arranged in right ascension order. This portion of the book contains the description of each object, most of which were made with a 20-inch f/4.4 Newtonian. I don't care for observing guides arranged in right ascension order simply because they are difficult to use as a reference. *The Plan* has numerous tables listing objects by type which help in locating objects if they have an NGC number. However, if you are looking for a double or variable star, you must thumb through the book page by page until you find it.

The descriptions are good and on par with actual appearance. I felt some were a little brief. Unlike other books, which use abbreviations in a comments or notes column, Vickers uses abbreviations in the descriptions, which makes for difficult reading. The author should have avoided them altogether, especially since they did not substantially reduce the text length.

The number of illustrations is impressive. Of the 682 objects listed,

568 are illustrated by photographs taken solely by the author.

The majority of photos are reproduced as negative prints and are similar in appearance to Vehrenberg's *Atlas Stellarum*, but are much lower in quality. The printing method chosen by the author affected the image quality. The images were scanned into a computer, enhanced, and printed on a laser printer. As a result, the images suffer. Negative prints offer better contrast than positive prints and eliminate the possibility of uneven toner distribution in an all-black background, a problem illustrated by the author's photo of the Rosette Nebula.

Yet even negative prints have their problems. Although open clusters, globular clusters, and small galaxies look fine, extended objects like M16 and M8 are washed out. Planetary nebulae look like stars — particularly NGC 2438 in the open cluster M46. Furthermore, negative prints don't do justice to dark nebulae.

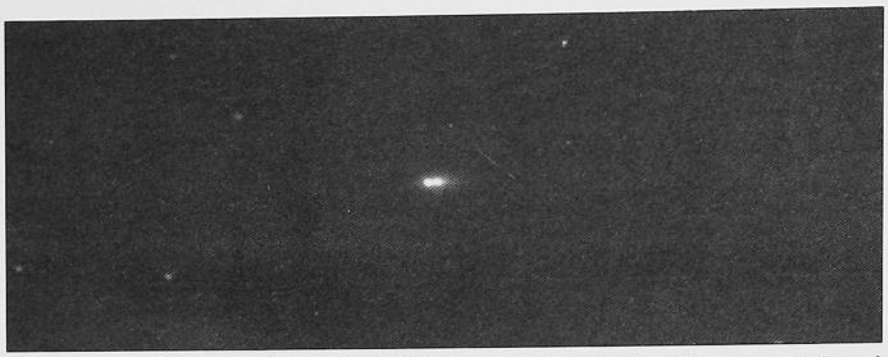
The Plan concludes with 50 star charts that pinpoint the location of each object within the respective constellation. The charts show only the brightest stars in each constellation, limiting their usefulness in locating objects.

Although this book is teeming with potential, its unflattering appearance may turn away a few readers. The cover, with its shadowed-blocked letters, resembles the title frame of a Japanese science fiction movie. Many of the photos are poorly cropped, making it difficult to determine where one photo ends and another begins. Hopefully a second edition of this work will clear up some of the problems, particularly the coded information and the photo quality.

The Supernova Search Charts and Handbook by Gregg D. Thompson and James T. Bryan, Jr. 96 pp. + 236 charts, hardcover and boxed, $100. Cambridge University Press, New York, 1989. (ISBN 0-521-26721-8.)

In academics, the more involved one becomes in a discipline, the more focused the study or research. The same holds true for amateur astronomy, a fact that is reflected in the literature where specialized observing books are beginning to outnumber more general texts.

A recent addition to this narrow classification is the Supernova Search Charts and Handbook by Gregg D. Thompson and James T. Bryan. The charts, with accompanying handbook, contain everything you will need to establish an extragalactic supernova search program.



Supernova 1990m in galaxy NGC 5493 photographed by Kim Zussman (14.5-inch f/8 Cassegrain, hypered Tech Pan film, 10-minute exposure.

Long the pursuit of a few dedicated observers, supernova hunting is attracting more attention. This boxed set contains 236 charts showing more than 300 galaxies well within reach of amateur telescopes. The charts are accompanied by a book that describes the proper use of the charts.

In the book, Thompson and Bryan begin building a strong case for visual supernovae hunting. They also describe how the charts were created and why they offer the best possible method for supernova hunting. Photographs of galaxies, as the authors point out, are not desirable for supernova hunting because the image orientation may not be noted, the photo may be cropped not showing the entire galaxy, the picture may show fainter stars than seen in your telescope, or the central portion of the galaxy may be overexposed, masking possible supernovae.

The book contains articles by professional astronomers outlining current supernova theory for the amateur who wants to understand these sudden and violent outbursts as well as hunt them. The book is abundantly illustrated with professional and amateur photographs; many are used to illustrate before and after shots of supernova while a few photos of galaxies which are not illustrated in the charts, but still may harbor a supernova.

The charts, which took years of trial and error to create, are not an actual representation of the how the galaxies appear visually. The authors tried to use freeh and drawings initially, but found the do not facilitate supernovae discovery. Problems with spacing between stars and galaxies are inconsistent and confusing.

As a result, the authors, independent of each other, came up with the idea of using photographs taken with professional equipment as the basis for their drawings. This eliminated the problem with spacing. The drawings show extended haloes, which although invisible in amateur instruments, may harbor a potential supernova. Additionally, HII regions are shown to avoid misidentification as a supernova. Once complete, visual observations were made to verify their accuracy.

The charts are designed to be viewed against a variable brightness light box. This provides a view that closely matches the galaxy when observed through the telescope. The authors provide information and drawing for constructing a dimmer-controlled light box. Each chart is named for the galaxies it depicts — if a group is shown, the chart is named for the brightest , or if all are the same magnitude, for the central galaxy.

Further, the images are inverted, which is ideal for observers using Newtonian telescopes. Observers using refractors or Cassegrain telescopes with a diagonal must view the charts from the back against a light box. Although this may seem inconvenient, the galaxy image is easy to see from the back side when viewed against any light source. However, the pertinent information regarding the galaxy is not visible.

The *Supernova Search Charts and Handbook* is one of the best tools for hunting extragalactic supernovae available for amateur astronomers. .

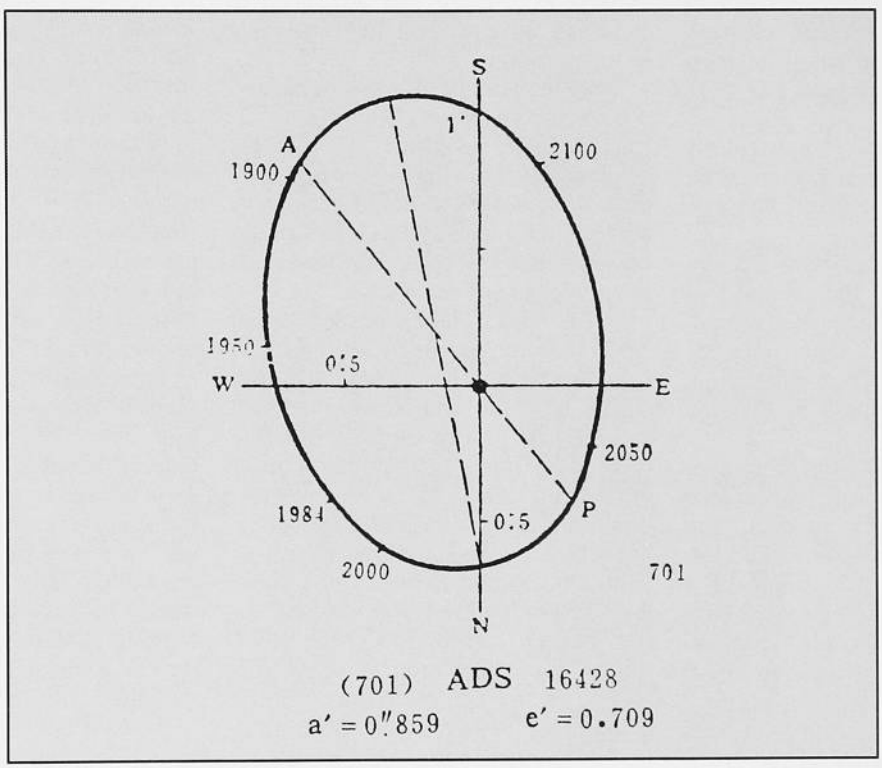
When not busy with his position at Celestron International, Mark J. Coco is an expert astrophotographer.

Double Stars

Double Stars in Pegasus

by Brian Skiff

Because Pegasus covers a large area of the sky, there are a large number of double stars in the constellation worth viewing with small to moderate apertures. The full sample of interesting pairs drawn from *Sky Catalogue 2000.0*, volume 2, includes about 40 pairs. Paul Brown and I viewed most of these as part of our survey of Pegasus deep-sky objects described elsewhere in this issue, and what follows is a discussion of the brightest and most interesting doubles.



To view many of the closer pairs Paul used an off-axis cardboard mask to stop down his 16-inch Newtonian to 6-inches aperture. This way the telescope was nearly diffraction limited, and it enabled us to compare views of the same pairs with my 6-inch refractor. Many observers find that by stopping their large f/4.5 Newtonians to f/6 or f/8 they get a remarkable improvement in image quality. This happens not just because the flaws in the image are made so faint they're hard to detect: the comatic flare is in fact much reduced, and by using only a small portion of it, even a poor mirror performs well. The cheapest way to get a really sharp 12.5-inch Newtonian might be to buy a standard 17.5-inch f/4.5 and use it with an f/6 mask.

As I've mentioned in this column before, some of the most pleasurable pairs for viewing are nearly equal, about magnitude 7 or 8, and around 2 arcseconds apart. **ADS 15007** is an excellent example. In my 6-inch scope at 80x the components appeared very close, even partially merged. I got a very good split by going up to 165x. At 295x I noted that the two stars are not quite equally bright, and it seemed the eastern star was slightly fainter, yielding a position angle of 90° rather than 270° as the catalog gives. It may be that either or both stars are slightly variable, or that the original measures (by Struve) gave the larger angle and it's been kept for consistency. Back at 80x I noticed a group of six 10th-magnitude and fainter stars about 5' southeast of ADS 15007 that form two triangles, making an interesting group with the close pair.

A similarly bright but unequal pair is **ADS 15092.** I could resolve them at just 50x. At higher power I estimated the magnitude difference (Δm) to be 2.5 to 3, but the *WDS* value is just 1.8 magnitudes. The *AGK3* star catalogue lists the stars individually with a magnitude difference of 2.3, so I feel confident in my disagreement with the double star catalogue. The *AGK3*, by the way, shows the two stars to have a common proper motion, so this is a physical pair.

Somewhat closer is **ADS 15767.** Here the catalogued Δm is 1.5, while my estimate was 1.75 — close enough for confirmation. The magnitude difference led to my needing 165x to resolve the pair cleanly. The *WDS* (and *Sky Cat2*) list distant companions to the west and southeast, but they are not of visual interest.

Our first bright, very close pair in Pegasus is **37 Pegasi** (ADS 15988). The present separation is a bit under 0".7, and the stars are closing much more rapidly than the most recent orbit predicts. On an average night in 1986, I used the Lowell 24-inch Clark refractor to resolve the pair when the telescope was stopped to 8-inches aperture, but in the so-so seeing glare from primary overwhelmed the companion with larger apertures. The magnitudes in the table have been computed from the total magnitudes and a photoelectrically-measured magnitude difference of ΔV = 1.43.

ADS 16292 is a relatively faint but unmistakable pair in the northern reaches of Pegasus, an excellent sight in my 6-inch at 80x. At 165x again there seemed to be a small Δm, with the southeastern star fainter (yielding a position angle of about 120° instead of 300°). What do you see here? About 3' southwest is a faint, uncatalogued pair, for which I estimate magnitudes of 12.5 and 13 and a separation of 8" in position angle 350°. A lone 13th-magnitude star lies between the two pairs.

Another unequal pair with a bright primary is **ADS 16389.** It was well shown by 165x; at 295x I estimated a Δm of 2.5 (ΔV = 2.6 by photoelectric measurement) and a position angle of 15° (position angle of 13° is catalogued).

The next tough, bright pair is **52 Pe-**

Double Stars in Pegasus

ADS	R.A. (2000)	Dec.	Mags.	sep.	p.a.	Date	Remarks
56	0h05.7m	+17°50'	8.7,8.7	7.7"	148°	1977	fixed > 1829
60	0h05.9m	+18°05'	9.5,9.7	3.43"	130°	1975	
15007	21h28.9m	+11°05'	7.5,7.5	1.8"	270°	1983	
15092	21h34.5m	+9°30'	7.9,9.7	7.0"	238°	1952	
15767	22h14.5m	+7°59'	6.8,8.3	1.4"	119°	1981	
15988	22h30.0m	+4°26'	5.7,7.2	0.68"	117°	1985	= 37 Peg
16292	22h49.7m	+31°19'	8.8,8.8	4.0"	927°	1971	
16389	22h56.9m	+11°51'	6.6,9.3	3.77"	13°	1986	
16428	22h59.2m	+11°44'	6.0,7.5	0.55"	312°	1988	= 52 Peg
16443	23h00.7m	+31°05'	6.7,9.2	3.4"	92°	1968	
16496	23h05.0m	+33°22'	8.1,8.1	2.7"	164°	1970	
16519	23h07.5m	+32°50'	6.3,7.5	8.4"	145°	1969	
16561	23h10.3m	+32°29'	7.5,8.3	0.6"	94°	1981	
16713	23h22.8m	+20°34'	6.7,9.7	5.85"	91°	1977	
16766AB	23h27.6m	+16°38'	8.2,9.3	2.8"	190°	1970	
AC			8.9,9.0	52.4"	66°	1953	
CD			9.0,9.5	3.2"	276°	1974	
16836	23h34.0m	+31°20'	5.7,5.8	0.53"	266°	1988	= 72 Peg

gasi (ADS 16428). My first view was in 1987 using the Lowell Clark. At 8-inches aperture I could see only a lump on the northwest side of the primary at 400x, but resolved the stars by opening up the telescopes iris diaphragm to 10-inches; 12-inches gave a clean split. Last autumn I saw a figure-eight shape in the 6-inch at 410x despite less-than-wonderful seeing. This is a good test pair for contrasty optics and good seeing. The stars are evidently closing slowly in the couse of their orbit and are estimated to have a period of about 290 years. Although the general shape of the apparent path shown in the figure is probably accurate, the two stars are somewhat closer than indicated there.

ADS 16443 was just visible in the 6-inch at 80x. At 165x I estimated a Δm of 2.5 and position angle of 90°, essentially identical to the catalogued values. Using his 16-inch at full aperture, Paul was not able to do much better at similar powers. Pairs with large Δms are particularly sensitive to seeing conditions.

ADS 16496 is another of the moderately-close, equal pairs fun to pick up at medium powers. Paul and I found independently that the two stars are not equally bright as the *WDS* indicates. We both estimated a Δm of about one-quarter magnitude. We both also noted a distant, third star to the west glowing at about 13th magnitude.

An easy, bright object for small telescopes is **ADS 16519.** With his telescope stopped to 6-inches aperture, Paul saw the stars as white and deep blue, colors that were more obvious to him at 6-inches than at 16-inches He also noted a very wide pair about 15' to the north. This is **Struve 2975**, consisting of two 10th-magnitude stars about 30" apart. The easternmost of these two stars was found to be a very close pair by Paul Couteau in 1971. Its stats are: magnitudes 9.8 and 10.7 and separation 0".8 in position angle 163° (1975). A sharp 12-inch telescope in good seeing should resolve this faint pair if used at high power.

A very tough double for my 6-inch is **ADS 16561.** On a good night in 1989, I saw the star as oval at 295x, and obviously double at 410x. At this power the merged Airy disks could be seen as seeing permitted. I estimated a position angle of 90° and Δm of 0.5, the latter being understandably a little off. A 9th-magnitude star lies a full arcminute east of the pair.

ADS 16713 is a relatively wide pair, but the comparatively large Δm may cause difficulty. I resolved it at 80x in my 6-inch, and with his 16-inch it was a quite easy for Paul. A photoelectric measurement shows the magnitude difference to be ΔV = 2.94, making it a good standard for comparing views of other pairs.

ADS 16766 consists of two pairs about an arcminute apart. The two pairs are relatively easy, and both Paul and I could resolve them at moderate powers. The brighter northeastern pair (don't look at the table of data yet!) has a Δm around 1.5, while the fainter southwestern pair have a small difference, which I estimated to be 0.2 magnitude. You'll notice, however, that in the table the magnitudes seem to be contrary to what I've just written. The photographic-blue magnitudes in the *AGK3* seem to confirm that the "CD" pair is the brighter, and I'm convinced the *WDS* (and *SkyCat2*) have the magnitudes messed up. Can you verify this yourself?

An excellent autumn seeing/optics test pair is **52 Pegasi** (ADS 16836). Separated by just over half an arcsecond and nearly equally bright, it should be interesting to view in 6- to 12-inch telescopes. Below 10-inches aperture, the pair will not be truly resolved, but should be recognizable at very high power. In the 6-inch at 410x last autumn I saw them in a "breadloaf" shape typical of bright pairs at half to two-thirds the Rayleigh resolution limit. The magnitude difference was small but discernable, as was the position angle.

This is the only pair discussed in this list that should have any kind of strong color. The two stars are mid-K giants, whose combined B-V = 1.38. Thus they should appear yellow-orange with sufficient aperture. Try this one several times before giving up; make sure it's within an hour or so of meridian passage (like dead overhead) to take advantage of the the seeing your observing site delivers.

Brian Skiff is an astronomer at Lowell Observatory and a co-author of the book Observing Handbook and Catalog of Deep Sky Objects *(Cambridge University Press, 1990).*

Small Scope Showcase

Atlases, Preservers of Time

by Alister Ling

My 17th edition *Norton's Star Atlas* looks like a turn of the century first edition. The binder is held together with masking tape. The star maps themselves are barely joined to the book by sixteen sewing threads.

My *Uranometria 2000.0* already seems fifteen or twenty years old; the corners of the binding are rounded. The coated covers revel the scars of time — scrapes and furrows crisscrossing against smaller objects in my backpack or observing accessory bag. Running down the right hand edge are a series of tags with abbreviation of constellation names. To jump into the heart of the northern Milky Way I simply lift up the tag marked "CEN CYG" to find myself on chart 119. Some friends are shocked at this treatment.

But this is not abuse. I guess it's a form of love. Throughout both atlases, pages are riddled with pencil marks and notes. *Norton's* still has the paths of various comets running from one page to the next, with numbers which denote sightings. I still use it to search for newly discovered comets, especially when one considers that the orbit may be off track or schedule, so I require a wider swath of sky than the smaller sections of *Uranometria 2000.0*.

Each object I saw got circled and colored on the maps as time went by. I can readily remember the night in Adirondacks where I pushed my 4.5" Tasco and pencil through crowded Sagittarius for the first time. A few twists of the declination control brought another wonder into the eyepiece and another mark on the chart.

One of the nicest aspects of that night was that I had to figure out the map layout given what I saw in the eyepiece. Quite different from these days of highly structured searches with *Uranometria*! Still, the more detailed atlas gets scribbled upon just as fondly, even more so than *Norton's*. My observing interests range over such a wide variety of deep-sky objects, that I can't possible remember what sort of luck I had with any particular object, so short notes in pencil find themselves onto most pages. It's particularly a section of my logbook, standing by at the telescope's side.

The Cygnus Milky Way is studded with dark nebulae. Photo by Steve Reed (28mm f/2.5 lens, 103a-F film, 30-minute exposure). Opposite page: The Cocoon Nebula is one of the finest examples of a deep-sky object in Cygnus. Photo by Chuck Vaughn.

Central Cygnus is awash in nebulosity. Photo by Martin C. Germano (5.5-inch f/1.65 Schmidt camera, Tech Pan film, 45-minute exposure.

The North America Nebula is visible to the naked eye. Photo by J.A. Farrell (7.5-inch Schmidt camera, 103a-E film, #29 filter, 15-minute exposure).

In effect, my *Norton's* almost reads like a biography of my early observing nights. It is a pleasant feeling to flip through it, the observing sessions coming alive once more. In twenty years, I will be able to do the same with my *Uranometria*.

Although no contemporary with *Norton's*, the Reverend T. W. Webb is readily associated with it. The use of the Herschel designations harks back to what an object looks like, not necessarily what it is. For many years I traveled across the sky with Webb's *Celestial Objects for Common Telescopes* and *Norton's*.

Webb was someone who truly appreciated the night sky for what it could give him. I think much of his enthusiasm rubbed off, and is with me still. The Reverend was awed by the thought of using telescopes as large as the Herschels or Lord Rosse, but he continued to wax lyrically about the beauty of the sky through his 3.7-inch (94mm) refractor. His sweeping power was 64x.

In keeping with a theme of "small" refractors, now becoming popular in the apochromatic designs, let's look at some of their advantages for deep-sky work. Obviously, they cannot compete with light buckets for galaxy observing, but their advantage shines through for wide field sweeping.

The inherently high contrast images provided by the well-baffled refractor and superior sharpness makes Milky Way observing a totally new experience for deep-sky observers. A 17.5-inch scope at 70x, with a curved field, comatic images (unless a corrector is used), often astigmatic, and bright sky background, often leaves one with a bad taste. Compare this to a 2° flat field of tiny pinpoints on a black sky! If you don't own a small refractor, try using your 80mm finder and bring up the magnification to around 20x.

This is one of the best ways to pick up dark nebulae. Notice that I didn't say "hunt." The high contrast and wide field makes dark nebulae stand out rather well. There are two ways of enjoying dark nebulae. Armed with your *Uranometria*, you can work slowly along the Milky Way, carefully noting down positions and appearances. Another method would be to let go and wander without a map, let your eyes be your guide, stopping here and there for a closer look. This is a most relaxing journey, a well deserved break from faint planetaries or galaxies. The eyes and mind feel refreshed afterwards, ready to work hard once more.

One of my favorite areas for sweeping is in northern Cygnus and the adjoining constellations of Lacerta and Cepheus. At 20x, the Cocoon stands out as a tiny blob at the end of an easy dark lane. It is a whole different perspective than trying vainly to star hop through myriads of 6th- and 7th-magnitude stars.

In talking about Cygnus, Webb mentions "its low-powered fields are overpowering in magnificence. I had at one time projected a survey of the wonders of this region with a sweeping power; but want of leisure . . . and the astonishing profusion of magnificence, combine to render a task hopeless for me which, I trust, may be carried through by some future observer." Will you be the one?

In his book, Webb noted several "interesting and fine fields." Two of them are (equinox 2000.0); 21h 08.3m +47°14', a curious horseshoe and magnificent field, and 22h29.5m +47°40', the position of 5 Lacertae, a deep orange star with blue component in a rich vicinity.

As amateurs, we often observe only the most notable deep-sky objects, the ones that will impress the neighbors or your observing companions. Unfortunately, we are rarely taught how to appreciate the more subtle things in life, to enjoy them for what they are. Give these "fine fields" a try. Take some slow deep breaths of clean, cool country air and let the sky do the work for you, don't strive to see what isn't there.

Another excellent wide field instrument is the naked eye. In the autumn sky, a few constellations are reminiscent of asterisms or fine fields in low proper views. To me, one of the most delicate is Capricornus. Its 3rd- and 4th-magnitude stars sparkle quietly above the southern horizon as Sagittarius sets in the west.

Pisces has two such lovely asterisms. One is the circlet, which I see as a small boat headed northeastward, sailing for the chain of stars ending at Alpha Piscium. A second chain hangs from high in the sky.

Sure, these asterisms and chains aren't impressive in any sense of the work, but their beauty is one of form and grace, not glamor. A nice way to observe them is to catch them second hand while scanning for meteors during an autumn shower.

Alister Ling is an observer and astrophotographer living in Canada. He has written for ASTRONOMY magazine.

Variable Stars

Fifty Columns of Observing

by David H. Levy

This is my fiftieth column about variable stars, the latest in a long series of attempts to encourage observers to take up an interest in these interesting objects. They are not fuzzy, nor do they move, and with a few exceptions they are not even surrounded with fuzz. Their excitement lies only in the fact that they change in brightness, and that these changes can usually be followed accurately by amateurs.

It all began in January 1980 as a bimonthly feature in the old *Star and Sky* magazine, and when that magazine stopped publishing a year later I wrote Dave Eicher with what I thought was a naive question: "would *Deep Sky* Magazine be interested in a column on variable stars?" I then thought that deep-sky observing meant only two things, fuzzy and distant. I was unaware of Dave's definition of a deep-sky object as almost anything beyond the solar system.

I was admittedly surprised that Dave actually wanted to inherit my variable stars column for his magazine. After some discussion we arrived at the idea for a column that would try to interest the magazine's readers in variable stars. Each month would see the introduction of new variables of a variety of types. Those were difficult days for Dave, as he tried to keep the publication going.

A year later, with the launch of the quarterly *Deep Sky*, the variable stars column underwent another transformation, and it continues to this day. Over the years it has evolved from a collection of essays about variable stars into a vehicle with which I try to express my amazement with the majesty of these celestial performers.

The column has pushed forward some lasting memories and friendships. One story is a conversation I had with Rik Hill, an observer from Arizona, about the frequency of outbursts of stars we call cataclysmic variables or dwarf novae. SS Cygni, the rnost popular such variable in the northern sky, had recently come down from its outburst magnitude of 8.3 and both of us had been estimating it at around 11.8. I mentioned to him that the star would probably not go into outburst again for more than a month; Rik said less than a month, and we bet $10 on the outcome. Two weeks later the star was back up at 3.3, and the resulting column began with a short statement: "I owe Rik Hill ten dollars."

Did I actually ever pay him? A few months after that Rik and I met again, this time as co-producers of the seventieth AAVSO spring meeting. At the banquet I presented him with a huge check in an elaborate frame to discourage him from actually trying to cash it to redeem the ten dollars.

Janet Mattei has been extraordinarily helpful in producing each of the fifty columns. As director of the American Assocation of Variable Star Observers she has provided charts and advice for article after article. Her pronouncement on this column's usefulness in getting new AAVSO members is heartening.

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Then there is Brian Skiff, whose writing output for this magazine probably exceeds anybody's except that of Dave. Skiff and I have had countless conversations about the writing we both do for this magazine, how it can be improved, and what Dave needs to do to make the magazine better. I always imagine Dave sighing and gulping for air whenever I call him with "Hey, Skiff and I were talking . . . "

Brian is a tornado of a writer. So omnipresent is his energy that it is dangerous to get too close to him. He's always holding onto something, either an idea-a-minute for one of his projects, or to some hapless object. During one conversation the pen he held went bouncing up and down so fast I thought it would fall apart. Finally the pen flew out of his hand, slammed against the ceiling, and returned to Earth in a meteorite swarm of plastic, refill and spring. But he had made his point.

Finally, there is Dave himself, asteroid 3617. We've talked variable stars in some pretty odd places, the oddest of which was on a rooftop overlooking a an empty highway overpass at 5:00 a.m. The editor and I had spent the night solving all the universe's problems. If I remember correctly, we were going to do a new book and I was going to start a new column. Just then we looked down as some engineers started blowing a whistle. This was really why we had stayed up all night; there was a huge explosion and the highway overpass crashed to the ground. What a sight! We never did collaborate on the book, and Alister Ling is now doing the column, called "Small Scope Showcase." But I still do variable stars. So it goes.

Here are some of the best variable stars visible in autumn skies.

021558 S Persei. This is Brian Skiff's favorite variable star, an irregular variable that recently has been undergoing a rare fading towards a minimum magnitude of 11.8. Although its listed maximum is 7.2, I have never seen it that bright. This star is in the same low-power field as the Double Cluster in Perseus. (AAVSO B and D chart.) Closeby to the northwest is **021258 T Persei**, a bright semiregular variable with a shallow variation of 8.2 to 9.1.

235350 R Cassiopeiae. A fine Mira-type star with a longer-than-typical period of 431 days. It has a five-magnitude range from 7.1 to 12.9. (AAVSO B and D charts.) .

David H. Levy is an experienced variable star observer and author living in Tucson. In May 1990 he discovered his sixth comet.

Scanning the Literature

Galaxies and Their Magnitudes, Part II

by Brian Skiff

In the last issue I started a discussion on how galaxy magnitudes are determined. Included was a description of the commonly-used UBV magnitude system and a definition of "total" magnitudes (B_T and V_T) for a nebulous or extended object like a galaxy.

Only B and V magnitudes were discussed in detail once they bear directly on visual observation. The dark-adapted visual response lies between the peak wavelengths of the two passbands and encompassed most of both. Magnitudes in the two colors correspond to the amount of energy reaching the observer from an object in the blue (B) and the yellow or "visual" (V) region of the spectrum. The two colors were closely tied to older magnitude systems based on photography rather than photoelectric photometry.

The "total" magnitude of a galaxy was defined as the amount of light emitted by an object extrapolated mathematically to infinite radius. Most of the light, of course, comes from the relatively very much brighter center of the galaxy. The problem in defining the magnitude comes when you try to find the edge. But, as I mentioned last time, galaxies observed to very low light levels (more than 100 times fainter than the brightness of the night sky) show no signs of ending: the glow from galaxian starlight reaches as faint as we can presently measure.

To avoid defining an edge for the purposes of magnitudes, it has proved convenient just to say a galaxy has infinite size. The mathematics (just as conveniently) works out so the object does not necessarily also have to be infinitely bright!

The procedure for deriving total magnitudes is described in the introduction to the *Second Reference Catalogue of Bright Galaxies* (*RC2*), by Gerard and Antoinette de Vaucouleurs, and Harold G. Corwin, Jr., published in 1976. The *RC2* precepts for determining magnitudes have been widely adopted in the professional astronomical community.

Although some of the analytical methods wed there are now outmoded by the advent of digital data (either from scans of photographic plates or directly from CCDs), the basic procedure remains in wide use.

One of the consequences of having a well-defined expression for total magnitudes is that results appearing in journals since publication of the *RC2* are differentiated as being "total" or "isophotal" — that is, a measure of all the light or just the magnitude within a certain isophote or brightness level. It is possible to draw contour lines around the periphery of a galaxy where the glow is equally bright, much as with contour lines of equal elevation on a topographic map. These lines of equal light are called isophotes.

The system set up in the *RC2* also defined the dimensions of a galaxy as the place where the halo fades to a brightness of B magnitude 25 per square arcsecond (called the B_{25} isophote), where the haze is equivalent to having a magnitude 25 star in every square-arcsecond box of sky. In a spiral galaxy this isophote is not a smooth oval as it would be in an elliptical galaxy, but a contour can be fit to the average and its size used in the catalogue. As noted above, this isn't really the edge of the galaxy, but proves a basis for comparison among galaxies that is rigorously standardized. Theory is no reason one can't report sizes on another system, but this one — like the magnitude system — is widely used.

When planning an observing session including galaxies, then, it would be ideal to be able to select them with consistent values for the total visual magnitude and size. Combining the two, we can calculate the average surface brightness, essentially the "magnitude per unit area" of the galaxy, which is an important predictor of visibility in a given aperture. Let's talk more about this particular number another time.

Let's take a look at some commonly-used sources for magnitudes and dimensions to see how they fit the ideal. Many amateurs still use information in *Burnham's Celestial Handbook*, a practice I feel should have long since ended, especially in publications like this one. Most of the galaxy magnitudes there derive from the venerable Shapley-Ames catalogue published in 1932 (H. Shapley and A. Ames, "A Survey of the External Galaxies Brighter Than the 13th Magnitude," *Annals of the Harvard College Observatory*, volume 88, number 2).

These magnitudes were determined on blue-sensitive photographic plates taken with wide-field patrol cameras. Since the galaxies were pretty small it was thought that their magnitudes could be calibrated against stars (by eyeball comparison) directly on the plates.

Well, sorta. When compared against modern total magnitudes, the Shapley-Ames magnitudes turn out to have systematic errors as a function of galaxy size, degree of elongation, and galaxy type — essentially they're off depending on how much the galaxies differ from star images. The fudge factor to shift them to total B magnitudes (remember, the UBV system didn't come along until 1953) is small compared to these other problems. Even when these systematic errors are compensated for, there's still an uncertainty of nearly half a magnitude in the result. And, of course, without additional observation, we have no way of shifting even the corrected Shapley-Ames magnitudes to V magnitudes, as we'd prefer. Burnham made no corrections at all, anyway, so it is best just to ignore them.

But we can't quite yet. Enter Fritz Zwicky, who compiled the vast *Catalogue of Galaxies and Clusters of Galaxies* (*CGCG*). He used the raw Shapley-Ames magnitudes to scale his magnitudes for brighter galaxies.

What is the correct magnitude for M95? To be sure, finding the right answer involves checking the proper sources and understanding what various magnitudes mean. Photo by Kim Zussman (modified 11-inch f/10 SCT, hypered Tech Pan film, 150-minute exposure.

Zwicky obtained film for all the fields in the catalogue using the 18-inch Schmidt at Palomar Mountain. Instead of ordinary tracking, he guided the telescope in a one-arcminute-square pattern. Thus all the images appear as little boxes on the film. (Even now the 8-inch Cassegrain guidescope on the little Schmidt has in its guiding eyepiece the grid-like reticle Zwicky used.) The idea again was that the reference stars and galaxies would all appear about the same, and the two could be compared directly — again, by eye.

Well, sorta. The Zwicky magnitudes turn out to have all the problems mentioned above for the older Shapley-Ames results plus two additional ones. The brighter, larger galaxies (brighter than 13th magnitude) were calibrated against Shapley-Ames magnitudes while fainter ones were calibrated against stars. Thus those brighter than magnitude 13.5 require a different kind of correction than those fainter than 13.5. To complicate matters even further, galaxies in the first volume of the six-volume catalog (including much of the Virgo cluster) have a different offset than objects in the latter volumes for reasons unknown, other than the work was done at a later time.

So the Zwicky magnitudes have errors depending on: 1) size: big galaxies have a different correction than small ones; 2) round galaxies get treated differently than thin ones; 3) type, i.e. surface brightness: high surface brightness galaxies that are starlike have a smaller correction than diffuse, low surface brightness objects; 4) magnitude: the Shapley-Ames *versus* the stellar calibration; 5) *CGCG* volume: volume I zero-point offset is different from the other volumes. Finally, the source of the *CGCG* problems is the same as for the Shapley-Ames: the galaxies aren't close enough to being starlike on the photographs.

Even when all these factors are accounted for as well as can be (and it isn't perfect), there's still the regular observational error. The eye just isn't a good detector for such measurements. The Zwicky magnitudes to appear in the forthcoming *RC3* are thought to have errors of ± 0.3 to 0.5 magnitudes after being corrected as above to B_T.

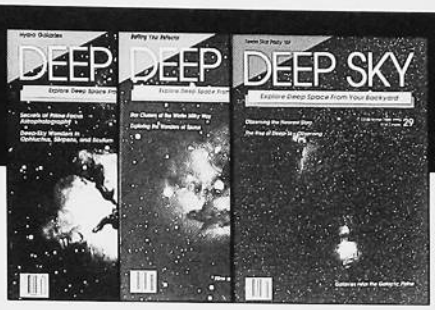
In a recent paper Greg Bothun and Mark Cornell examined Zwicky magnitudes for faint galaxies ("The Faint End of the Zwicky Magnitude Scale: CCD Isophotal Magnitudes Versus Zwicky Magnitudes" in *Astronomical Journal* **99:**1004, March 1990). They obtained B magnitudes within various isophotes for about a hundred galaxies and compared them in various ways with the original Zwicky data. Specifically, they computed magnitudes within isophotes from magnitude 22 per square arcsecond down to magnitude 27, which was as faint as their data was reasonably accurate.

One comparison was to see what isophote (brightness) level the Zwicky magnitudes correspond to. On average, the Zwicky magnitudes refer to the B isophote, the contour enclosing the B magnitude 25 per square arcsecond light level. But Zwicky's data scatter over a wide range: for a third of the galaxies, the limiting surface brightness was between magnitudes 22.5 and 24, missing as much as half the light of the galaxies involved, and making the Zwicky magnitudes up to 0.75 magnitude too faint. For a few others the Zwicky magnitudes include light beyond the magnitude 27 isophote; they are potentially total magnitudes.

Not surprisingly, Bothun and Cornell conclude that the raw Zwicky magnitudes are not well-defined. By means of other tests, they note that differences between magnitudes are not reliable either a galaxy with Zwicky magnitude 14.5 is not necessarily 0.5 magnitude brighter than one he calls 15.0. They find evidence also that the Zwicky magnitude scales are different for spirals and elliptical galaxies, essentially caused by the surface brightness effect we already discussed.

My main point here is that amateurs almost always use magnitudes from the Zwicky catalogues as though they are total visual magnitudes; I hope the foregoing is enough to convince you that they are not, and that the difference is not small.

Brian Skiff is an astronomer at Lowell Observatory and the coauthor of Observing Handbook and Catalogue of Deep-Sky Objects, *published this year by Cambridge University Press.*



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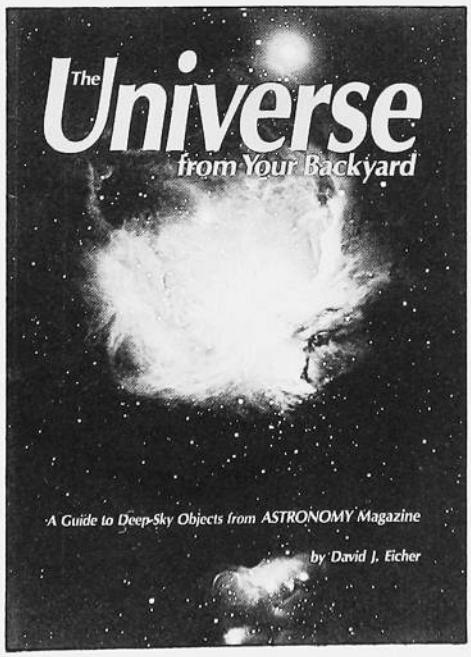

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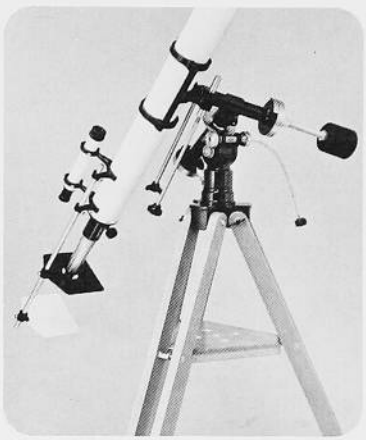

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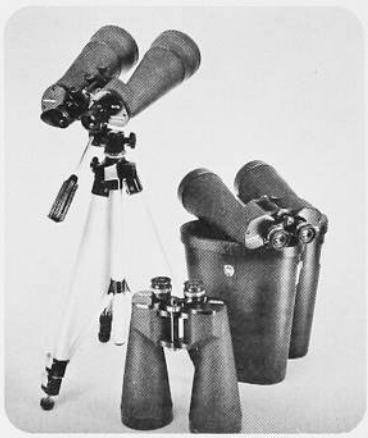

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A full line of quality 2" and 1-1/4" diagonals to improve your viewing pleasure.

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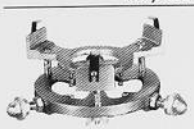

A new concept in lightweight, adjustable aluminum mirror cells.

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University Optics now offers a full line of focusing mounts for every telescope maker's most exacting requirements.

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Vega-1, a rack and pinion focuser for 1-1/4" eyepieces.

Basic construction is aluminum with a chrome plated brass draw tube and helical rack and pinion. 4 tension adjustment screws. Racked-in height is 3". Provision for single vane holder. All hardware included–**$49.95**

The Vega-2 is the perfect match for those large Newtonians.

For years, the first choice of custom reflector builders, the Vega-2 offers a helical-cut rack and pinion, all metal construction, and large 1-1/2" focusing knobs. Takes 2" O.D. eyepieces and comes with a 1-1/4" adapter. Racked-in height is 3-3/4". All mounting hardware included–**$72.95**

The Vega-3 and Vega-5 are precision low-profile focusers.

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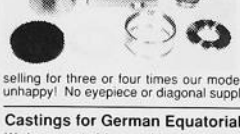
We are now offering our own cast iron counterweights and since they are made here in the U.S.A., we can save you a "ton" of money. We bore to your shaft size at no extra cost. Tightens on your scope with 1/4-20 locking bolt. **5 lb–$19.95, 10 lb–$29.95, 50 lb–$69.95.** Weights are F.O.B. Ann Arbor, Michigan. Call toll free for exact UPS charges to your door.



80mm Refractor Kit.

This astronomical quality kit features a high performance air-spaced multi-coated lens with a 500mm focal length. Uses our Vega-4 2" focuser. All parts beautifully machined of brass and aluminum. Screwdriver assembly in about 15 min. Warning! Don't put this scope next to similar size scopes selling for three or four times our modest price. The other owners will be very unhappy! No eyepiece or diagonal supplied–**$289.95**

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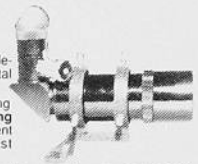

Our 8x50 finders come with a 1-1/4" wide-field eyepiece and diagonal. All-metal construction. Fully coated optics.

Choice of white or black. Mounting bracket is extra. **Price–$99.95. Mounting bracket** for above finder with 6 adjustment screws fits C-8, 2080, and most reflectors–**$19.95**

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Our 11x80mm is the "ultimate" giant viewfinder!

It's a fantastic viewfinder. It's a versatile rich-field telescope. It's a compact nature study scope. It has an Amici prism for correctly oriented images. We added a fine quality rack and pinion, a crosshair eyepiece, and a camera tripod mounting block to round out the package. Beautiful satin black finish—**$279.95**

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Our years of experience supplying binocular viewers assure you the finest product on the market. Our unit features the exclusive removable multi-coated Barlow image transfer lens system. Our unit fits any 1-1/4" telescope. Interpupillary adjustment with indexed scale–**$475.00**

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We have some new additions to the world's most exciting line of compact, lightweight, and affordable 80° plus eyepieces. The new **16mm** with an 84° field gives a brilliant performance. All **Wide Scans**™ feature only the finest select Japanese optics throughout. Full multi-coating. The 82° field **6mm** and **8mm** will be available in the summer of 1990.

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Professional Camera Adapter couples your camera to any 1-1/4"" focuser. For first focus and eyepiece projection. Use with camera T-ring listed below—**$34.95**

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There's no question large aperture reflectors like John Vogt's excellent 30" f/3.8 produce deep sky views rivaling those I've seen in major observatories. But his scope, like yours, is limited in field sharpness. The main offender is coma, an aberration which makes stars look like blurry comets. Visually and photographically, the faster the scope the worse the effect.

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1. maximum reduction in coma and field curvature without compromising spherical aberration and color correction

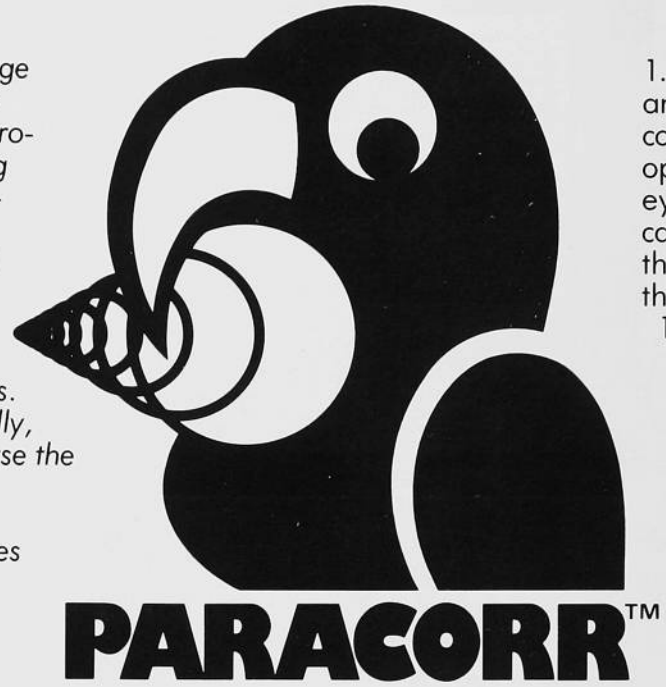
2. major sharpness improvement for all popular focal ratios

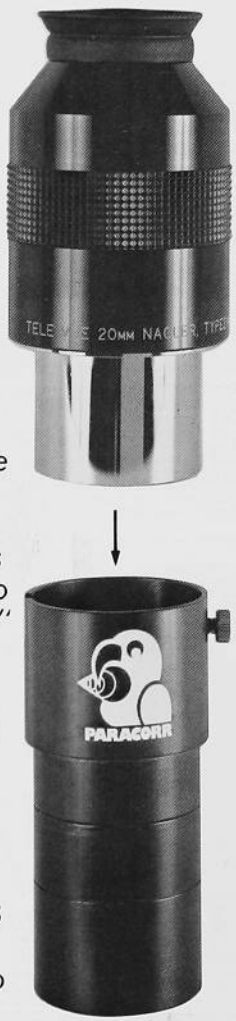
3. equally effective visually or for 35mm film

4. as convenient to use as a Barlow lens

I hope you agree that Paracorr, the coma eater, is the missing link necessary to fully enjoy your "DobNewt."

—Al Nagler





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Rival a Schmidt Camera? Mount your 35mm SLR to Paracorr, and the quality of full frame photos will be spectacular since star image sizes are designed to be less than .001 inch over the field for an f/4.5 mirror.

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Paracorr drops in like a Barlow lens. With only a slight 1.15x magnifying factor, an f/4.5 telescope becomes an f/5.17. While optimized for Tele Vue eyepieces, other makes can be used. Of course the better the eyepiece, the better the results. The 1¼" Paracorr is parfocal with most Tele Vue eyepieces. The 2" Paracorr requires about ½" in-travel from your current focus location. Can't be simpler for any scope, any eyepiece, and any 35mm SLR camera.

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A) parfocal 2"-1¼" adapter
B) 2" eyepiece holder
C) lens assembly threaded for T-rings

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